Stormwater Management Design Manual

First Edition
June 2008

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This Manual is based on the June 2007 version of the Stafford County, VA. Stormwater Management Design Manual

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Chapter 1

1 Introduction

1.1 Authority

The stormwater management provisions of the Culpeper County Code[1] were adopted to establish requirements for the management and control of stormwater runoff from developed properties in the County during and after their construction. This manual contains guidance for designers to assist them in meeting those requirements. It serves as a supplement to State and Federal design manuals that govern stormwater management design including the following:

Virginia Stormwater Management Handbook, Volumes I and II, prepared by the Virginia Department of Conservation and Recreation dated 1999, as amended.

Virginia Erosion and Sediment Control Handbook, prepared by the Virginia Department of Conservation and Recreation dated 1992, as amended.

Low Impact Development Hydrologic Analysis, United States Environmental Protection Agency, Office of Water, EPA 841-B-00-002 dated June 1999, as amended.

Low Impact Development Design Strategies: An Integrated Design Approach, United States Environmental Protection Agency, Office of Water, EPA 841-B-00-003 dated June 1999, as amended.

Virginia Department of Transportation (VDOT) Drainage Manual, prepared by the Hydraulics Section of the Virginia Department of Transportation dated 2002, as amended.

Prince Georges County Bioretention Manual, prepared for Prince Georges County, Maryland, November 2001, Revised December 2002, Prince Georges County, Maryland.

[1] Chapter 8, Erosion and Sedimentation Control, Chapter 11A, Stormwater Management, Culpeper County Code

Low Impact Development Supplement to the Northern Virginia BMP Handbook (Under development at the time of this writing), Northern Virginia Regional Commission, 2007.

Collectively, these are referred to in this manual as the Design Manuals.[1] These manuals should be used by designers to ensure that standard, acceptable design practices are used in developing their stormwater management designs. This manual provides further guidance where local conditions and requirements differ from the State and Federal manuals. The manual is structured to provide guidance throughout the development process, from the development of a stormwater management concept to a stormwater management design to post-construction (as-built) requirements.

1.2 Applicable Programs and Regulations

The designer is responsible for knowing the details of all applicable ordinances and regulations before submitting a stormwater management concept or design plan. The developer is responsible for securing applicable Federal and State permits and should keep the County informed as to their status. The following is a list of some local, State, and Federal programs and regulations related to stormwater management and erosion & sediment control that may be applicable to land development projects in the County. This list is not intended to be all-inclusive and there may be other programs and regulations that are applicable to a particular development site in the County, depending upon its specific location.

Virginia Stormwater Management Act and Regulations administered by the Virginia Department of Conservation and Recreation

Virginia Erosion & Sediment Control Act and Regulations administered by the Virginia Department of Conservation and Recreation

Chesapeake Bay Preservation Act and Regulations administered by the Virginia Department of Conservation and Recreation

Virginia Stormwater Management Program (VSMP) administered by the Virginia Department of Conservation and Recreation

Virginia Dam Safety Act and Regulations administered by the Virginia Department of Conservation and Recreation

Section 404 of the Clean Water Act administered by the US Army Corps of Engineers (USACE) and the US Environmental Protection Agency

[1] Where information in one of these documents conflicts or differs from information in another, that from the reference higher on this list should take precedence of that from a reference lower on this list.

Virginia Water Protection Permits administered by the Virginia Department of Environmental Quality

National Flood Insurance Program administered by the Federal Emergency Management Agency

Chapter 8, Erosion and Sediment Control, Culpeper County Code administered by Culpeper County Virginia

Chapter 11A, Stormwater Management, Culpeper County Code administered by Culpeper County, Virginia

Appendix A, Zoning Ordinance, Culpeper County Code administered by Culpeper County, Virginia

Appendix B, Subdivision Ordinance, Culpeper County Code administered by Culpeper County, Virginia

1.3 Stormwater System Design Basics

Stormwater systems in the County are comprised of two parts:

1) **Drainage systems** to convey storm and other surface flows through the land development project; and,

2) **Stormwater management facilities** to minimize the adverse impact of increased stormwater runoff on downstream properties.

The ultimate objective of drainage systems and stormwater management facilities is to convey and control stormwater from a developed site so that the site itself and the downstream areas are not adversely affected by the increased runoff caused by the development and to reduce the amount of pollutants leaving the site.

Traditionally, stormwater drainage systems have consisted of natural streams and swales, engineered open conveyance channels, storm sewers, and road culverts while stormwater management facilities consisted of detention ponds, infiltration facilities, and other best management practices (BMPs). These BMPs reduce peak runoff rates from a developed site to pre-development condition. They also detain runoff which allows pollutants to settle out before being released.

These measures release cleaner runoff at rates no more likely to cause flooding downstream than before development, but they do not address the erosion potential posed by the shear increase in runoff volume from a developed site. To address this, stormwater management systems are designed to detain the volume of runoff from the most frequent storms (1-year, 24-hr) on site and release it over the entire 24-hour period of the event.

Ultimately, however, these measures allow almost all the increased runoff caused by the development to leave the site. A relatively recent development in stormwater control systems is low-impact development (LID). Under this approach, integrated management practices (IMPs) are used to control and actually retain stormwater at the source of the runoff and more closely replicate pre-development hydrology. Typical IMPs include bioretention facilities, dry wells, filter strips, buffer strips, grassed swales, rain barrels, cisterns, and infiltration facilities.

1.4 Stormwater Management Design Review and Approval

The County is responsible to ensure that stormwater management features built in the County comply with regulatory requirements. It does this by reviewing stormwater management plans at every stage of development.

Applicants must demonstrate compliance with requirements in their plan submissions. It is significant to note that compliance with technical design requirements alone is not sufficient for approval. Compliance must be *demonstrated* during the review process. Failure to do so shall be cause for rejection of the plan.[1] Plans submitted for County review should be comprehensive, organized and presented so that compliance is evident to someone familiar with requirements but unfamiliar with the project, project site, or surroundings.

Some common barriers to effective plans are:

The use of values in supporting computations that are not evident in drawings. These often include drainage areas, land uses, and time-of-concentration flow path segments,

The inclusion of computer output which is not summarized, cross-referenced, or indexed to indicate its relevance in the design,

The depiction of information unrelated to stormwater management design which detracts from or obscures stormwater management information,

Reliance upon information contained in other plans to support the presented concept or design,

Failure to obtain and present information required to support elements of design, e.g., geotechnical recommendations for design and construction of a pond embankment,

[1] Culpeper County Code § 11A-13(b)

Depiction of drainage divides that are incomplete, do not honor the underlying topography, or do not show the underlying topography at all,

Reliance upon off-site facilities without demonstrating their adequacy to meet the code requirement.

1.5 Conditions of Stormwater Management Design Plan Approval[1]

Once approved, a Stormwater Management Design Plan carries the following conditions:

The provisions of the approved plan must be adhered to during and after construction.

No changes to the approved plan may be made without review and approval by the program administrator. Examples of allowable changes are:

Use of a higher class pipe than proposed.

Slight realignment of drainage system having no impact on hydraulic grade line.

Recordation of a final plat for a section of a multi-section subdivision (or initiation of construction in a section) does not vest the approval of the design plan for the remainder of the subdivision. If the design plan expires, the applicant must file for re-approval.

The effects of approval of any plan shall not transfer to any other plan. Enforcement or non-enforcement of any specific requirement during review and approval of any plan shall not constitute a precedent to be relied upon during preparation of any other plan.

[1] Culpeper County Code § 11A-16

Chapter 2

2 Stormwater Drainage System Design

2.1 Introduction

This chapter discusses stormwater drainage design in Culpeper County. Stormwater drainage means the collection and conveyance of storm and other surface flows through the land development project in a manner to prevent flooding of structures associated with properties and erosion of channels. Stormwater drainage systems include stormwater conveyance channels, storm sewers, and culverts. Drainage systems do not include facilities for storage, treatment, or disposal of stormwater runoff. Design of those systems is discussed in Chapter 3 in this manual.

2.2 General Requirements

Stormwater drainage systems are to be designed and constructed to conform with Virginia Department of Transportation (VDOT) design standards as provided for in the latest edition of the VDOT Drainage Manual and the VDOT Road and Bridge Standards except as noted in this chapter.

The method(s) of drainage (i.e. constructed channels, storm sewer system, etc.) proposed for the site must be in accordance with an approved Stormwater Management Concept Plan as detailed in Chapter 5.

All drainage systems must be designed and sized based on ultimate development. They must be designed to convey both onsite and offsite surface waters. In addition, an adequate and safe overflow path for the 100-year flow must be provided should the drainage system be inoperable due to blockage.

Easements must be provided for stormwater drainage systems in accordance with requirements in this manual.

2.3 Hydrologic Computations

There are a variety of hydrologic computation methods available to the designer. It is the designer's responsibility to know the limitations of each method and to select the method that is most appropriate for a particular design or analysis and provide their reasoning for choosing the particular design analysis.

2.4 Runoff Computations

Five methods for calculating runoff are available. Selection of the appropriate method is based upon the size of the drainage area and the output information required. The following table lists acceptable calculation methods for different drainage areas and output requirements.

AVAILABLE METHODS[5]

1) Rational Method
2) Modified Rational Method
3) Graphical Peak Discharge Method
4) Tabular Method
5) Unit Hydrograph Method

Output Requirements	Drainage Area	Appropriate Method
Peak Discharge Only	Up to 200 acres	1, 3, 4, 5
	Up to 2000 acres	3, 4, 5
	Up to 20 square miles	4, 5
Peak Discharge and Total Runoff Volume	Up to 200 square miles	2, 3, 4, 5
	Up to 20 square miles	4, 5
Runoff Hydrograph	Up to 20 square miles	4, 5

When hydrologic methods require intensity-duration-frequency information:

1. For the TR-55 Method or the Peak Discharge Method use the data in Appendix 5A "a and b Constants for Virginia" found in Volume II of the Virginia Stormwater Management Handbook, 1999,
2. For the Rational Method or the Modified Rational Method, use the data in Appendix 4B "24-hour Rainfall Data of Virginia" found in Volume II if the Virginia Stormwater Management Handbook, 1999.

When designing a storm sewer network for multiple drainage basins, the designer may compute and tabulate flows using the Rational Method provided that flows to all entrance structures with a drainage area greater than 200 acres are computed using other acceptable hydrologic methods and the time of concentration is computed using the SCS method.

[5] The rainfall data shall be according to the latest NOAA or VDOT Hydraulic Design Advisory.

2.5 Stormwater Conveyance Channels

Stormwater conveyance channels must be designed to convey the peak discharge from a ten-year storm with a minimum freeboard of 1.5 times the flow depth or one foot, whichever is less. Channel linings must be selected using procedures in either the VDOT Drainage Manual or the Virginia Erosion and Sediment Control Handbook (latest edition). Low flow sections are recommended in the design of channels with large cross sections.

2.6 Storm Sewers and Culverts

An adequate and safe overland flow path for the 100-year ultimate condition storm shall be shown on plan view in case of storm sewer blockage. Detailed cross sections and a water surface profile computation shall be provided where flooding of structures could be possible.

Storm sewers and culverts shall use reinforced concrete pipe (RCP). However High Density Polyethylene (HDPE) or Polyvinyl Chloride (PVC) pipes could be used for storm drainage in (a) Driveway Culverts, (b) Commercial Projects, and (c) Segment of residential project within VDOT right of way, with the following specifications:

RCP

RCP shall meet the three-edge bearing strength test requirements for ASTM C76 Class III RCP of better.

Non-residential projects shall be in accordance with VDOT standards.

HDPE and PVC Pipes

The maximum size allowed is 48”. However, in locations within the state right-of-way and where approved by VDOT, maximum culvert size may be sixty (60) inches

The maximum depth of trench, when measured from final grade, shall be ten (10) feet, and the minimum cover shall be eighteen (18) inches.

HDPE pipe shall conform to ASTM F2306/F2306M-05 “Standard Specification for 12 to 60 in. [300 to 1500 mm] Annular Corrugated Profile-Wall Polyethylene (PE) Pipe and Fittings for Gravity-Flow Storm Sewer and Subsurface Drainage Applications”. PVC Pipe shall meet the requirements of ASTM F949, “Standard Specification for Polyvinyl Chloride Corrugated Sewer Pipe with Smooth Interior and Fittings.”

Joints for HDPE and PVC shall conform to ASTM D3212, “Standard Specification for Joints for Drain and Sewer Plastic Pipes Using

Flexible Elastomeric Seals". Gasket shall meet or exceed the requirements of ASTM F477-07, "Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe."

Installation of HDPE and PVC pipe and fittings shall be in accordance with the more stringent of the following two: (a) ASTM D2321, "Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications". This section of ASTM includes foundation, embedment and backfill material requirements, trench excavation, installation, joints, inspection, handling and storage of pipe material. (b) The current VDOT standards.

In residential installations, bond release and acceptance shall require visual inspection. County may choose to require mandrel testing during visual inspection. Pipe shall be replaced where deflection exceeds 7.5% of the initial inside diameter. Pipe in non-residential setting shall require visual inspections to ensure proper installations with requirements similar to residential installations.

A residential project with more than ninety (90) percent of the total storm sewer located in the state right-of-way, when measured in length, may use HDPE or PVC pipe outside the state right-of way with prior approval from Program Administrator. The requirements for bond release of HDPE or PVC storm sewer, when used in a subdivision outside the state right of way, shall be consistent with the bond release of storm sewers in segments of the subdivision within the state right of way.

An adequate and safe overland flow path for the one hundred-year ultimate condition storm must be calculated and shown on design plans in case of storm sewer blockage. For storm sewers, use 100 percent inlet blockage (non-operative inlet) to model overland relief. For culverts, use the following blockage parameters.

Culvert Inlet Diameter	Blockage
< 24 inches	100 %
24-48 inches	50 %
> 48 inches	25%

Detailed cross sections and water surface profile computations must be provided where flooding of structures could be possible.

In a channel used by anadromous fish, the outlet end of the culvert pipe should always be slightly submerged. If multiple pipes are to be installed, the invert of one pipe should be at least 6 inches below the others, at least on the inlet end, that all the other pipes and the outlet end of that pipe should be slightly submerged.

Chapter 3

3 Stormwater Management Facility Design

3.1 Introduction

This chapter discusses stormwater management facility design in the County. Stormwater management means the collection, conveyance, storage, treatment, and disposal of stormwater runoff in a manner to prevent accelerated channel erosion, increased flood damage, and degradation of water quality.

In accordance with the County's stormwater management ordinance, there are generally three methods of addressing stormwater management (SWM) requirements: On-site SWM Facilities; Regional SWM Facilities; and Low-Impact Development Site Planning with Integrated Management Practices (IMPs). These facilities and practices must be designed and constructed to conform with the Stormwater Management Design Manuals and other guidance documents listed in Chapter 1 of this manual except as noted in this chapter.

3.2 On-Site Stormwater Management Facilities

In general, all land development must provide for stormwater management on site. Exceptions to this include cases in which stormwater management requirements are met by an existing or proposed off-site facility. In any case, methods of stormwater management proposed for the site must be in accordance with an approved Stormwater Management Concept Plan.

Conventional SWM facilities must be designed and constructed to conform with the Virginia Stormwater Management Handbook, Volumes I and II, prepared by the Virginia Department of Conservation and Recreation dated 1999, as amended. Integrated management practices must be designed and constructed to conform with those handbooks and the Low Impact Development Design Manuals. Conventional SWM facilities shall be platted on separate tracts intended for that purpose.

For SWM ponds that will initially serve as temporary sediment basins during construction, Culpeper County requires that they be constructed in accordance with the design for stormwater management and then modified to serve temporarily as sediment basins. The principal exception is the water quality orifice. A larger orifice may be installed initially to serve as an outlet for the perforated tubing encased in gravel and wrapped in filter fabric. After the sediment has been removed the water quality orifice is installed, usually by grouting a short segment of PVC pipe having the inside diameter of the required water quality orifice.

All riser structures must be concrete unless a substitute material has been specifically approved by the Program Administrator.

Easements must be provided for stormwater management facilities in accordance with requirements in Section 3.8 and Chapter 7 of this manual.

3.3 Stream Channel Erosion Control

SWM designs must provide twenty-four-hour extended detention of the runoff from the one-year, twenty-four-hour-duration storm. This requirement is satisfied by a full LID design as defined in Section 3.6.1.1 of this manual. (See Culpeper County SWM Ordinance section 11A-24)

3.4 Flooding

SWM designs must reduce the post-developed peak discharge rate from the ten-year storm to no more than the pre-developed peak discharge rate. This requirement is satisfied by a full LID design as defined in this manual.

3.5 Water Quality

See Culpeper County SWM Ordinance sections 11A-19 through 11A-21. Other methods may be deemed acceptable on a case by case basis.

3.6 Low-Impact Development with Integrated Management Practices

In Culpeper County, Stormwater Management Concept Plans must use low-impact development site planning to the maximum extent practicable. A full LID design must be considered in every case except as indicated below. However, the feasibility of LID design will vary based on factors such as soils, topography, downstream drainage, proposed land use, cost, and others.

3.6.1 Levels of LID Design

Three levels of LID design are recognized in the county.

3.6.1.1 Full LID Design

A "full LID design" is one which:

1) Honors existing drainage divides and maintains times of concentration to each drainage outfall to at least that of the existing site;

2) Employs site design techniques and distributed integrated management practices to retain runoff so that no more stormwater leaves the site in the design storm[1] than would be expected if land cover were woods in good condition;

3) Employs distributed integrated management practices to control runoff peak flows of the design storm to no more than those expected if land cover were woods in good condition; and,

4) Employs distributed integrated management practices to retain one-half inch of stormwater from all impervious surface.

LID designs which meet all these criteria satisfy all water quality, stream channel erosion, and flooding requirements listed in Culpeper County Code Sections 11A-19 through 11A-24.

3.6.1.2 Partial LID Design

A "partial LID design" is one which:

1) Meets all the criteria for a full LID design in one or more of its drainage areas totaling 70% or more of the site, but not on the remainder of the site; or,

2) Meets the time of concentration requirement needed for a full LID design and at least two of the remaining criteria needed for a full LID design in all of its drainage areas.

All requirements not met by LID practices must be met using conventional stormwater management measures.

[1] The design storm is to be the greater of the rainfall at which runoff begins for woods in good condition with a modifying factor and the one-year, twenty-four-hour storm event. See Section 4.5.

3.6.1.3 Limited LID Design

A "limited LID design" is one which employs some practices associated with LID design but does not meet the criteria for a full or partial LID design.

3.7 Determining "Maximum Extent Practicable"

Culpeper County Code requires SWM concepts to utilize LID to the maximum extent practicable. The appropriate level of LID design for any particular development project is decided during review and approval of the SWM Concept Plan for the site. This measure is subjective; however, the following guidelines will be applied to determine compliance with this requirement.

New development on sites where steep slopes (15% or greater) or poor soils (hydrologic groups C and D) occupy 50% or more of the site need not attempt a full LID design.

Engineering analysis (data and computations) of a site for suitability of LID design must be evident in the SWM Concept Plan.

New development where impervious surface will cover 70% or more of the area to be developed need not attempt a full LID design.

New development in which LID retention facilities would occupy more than 10% of required open space may use a partial or limited LID design using no additional LID retention facility area.

Any previously-developed site not previously developed using a full or partial LID design may employ a limited LID design.

Redevelopment projects need not attempt a full LID design.

Projects which propose to improve existing inadequate downstream channels may be exempt from the requirement to attempt a full LID design subject to the approval of the Program Administrator.

3.8 Easements for IMPs

Drainage and access easements must be provided for integrated management practices on lots or parcels in accordance with requirements in this manual.

3.9 Geotechnical Study Requirements

A geotechnical study consisting of a field investigation, laboratory testing, and a geotechnical engineering analysis with recommendations is required as part of the design for all detention basins, retention basins, infiltration facilities, bioretention facilities, constructed wetlands, and underground detention facilities. Geotechnical studies for other types of BMP facilities may be required on a case-by-case basis depending upon the complexity of the proposed facility design and the extent to which its proper design and performance may be affected by the geotechnical properties of the site.

Results of the geotechnical study are to be documented in a geotechnical report prepared by a licensed geotechnical engineer. This report is to be submitted with the Stormwater Management Design Plan and geotechnical recommendations must be identified on the design plan.

Information to be included in the geotechnical report will vary depending upon the facility type and the designer should consult the Virginia Stormwater Management Handbook (and its associated references) and the project geotechnical engineer for more specific guidance on pertinent geotechnical information needs by BMP type. However, at a minimum the following information should be provided in the report:

- Identification and description of the proposed facility.
- Site map showing locations of soil borings and test pits.
- Soil logs containing unified soil classification system (USCS) by depth.
- Depth to seasonal water table and bedrock.
- Degree of mottling and chroma of mottles.
- Presence of porous or fractured bedrock, mica schist, and iron pyrite.
- Other soil properties as deemed appropriate by the geotechnical engineer.
- Geotechnical engineer's recommendations.

For infiltration practices, including bioretention facilities associated with LID designs, the report must indicate appropriate subsoil infiltration[1] and at least two feet depth to seasonal water table and bedrock to allow the facility to operate as designed.

[1] Appropriate subsoil infiltration rates are 0.52 – 8.27 inches per hour (Virginia Stormwater Management Handbook Section 3.10, page 3.10-5); however, the Handbook also requires that a factor of two be applied to the minimum infiltration rate as a margin of safety against clogging over the lifetime of the facility (Virginia Stormwater Management Handbook, Section 3.10, page 3.10-14). Therefore, the report must indicate a subsoil infiltration rate between 1.04 and 8.27 inches per hour.

3.10 LID Plan Elements And Submission Requirements

3.10.1 Concept Plan

During the concept phase, the engineer shall demonstrate, conceptually, how the integrated management practices (IMPs) with bioretention and/or other environmentally sensitive site design practices will be incorporated into the Plan.

During the conceptual phase, the engineer shall evaluate the feasibility of creating a hydrologically functional site design that satisfies the overall objective by completing the LID Site Design Checklist and LID Computations Worksheet (Appendix 10.2). The procedures in the checklist are aimed at disconnecting and minimizing the impervious areas and planning drainage flow paths so that the post development time of concentration can be maintained as close as possible to the predevelopment conditions. Maximizing the runoff travel time to closely approximate the predevelopment conditions is among the very first steps in LID design. The concept phase should occur concurrently with the preliminary plan submission, when applicable.

The engineer should provide general information on preliminary soil test results to confirm the suitability of onsite soils for LID practices with the Concept Plan. Soil Survey of Culpeper County, Virginia, may be used during the conceptual stages, with other supplemental information as needed.

For details on concept plan requirements, refer to Chapter 5.

3.10.2 Site or Construction Plan

Once the LID SWM concept has been approved by the County, the engineer may submit a stormwater management design plan to address SWM. In this phase, the engineer will determine how to distribute the bioretention and other environmentally sensitive design practices uniformly across the site by emphasizing on a source control approach. In this iterative phase, the engineer shall develop a plan to meet the SWM requirements. A detailed geotechnical report is performed at this time, or earlier, to evaluate the on-site soils for LID suitability. In situations where the bioretention facilities are proposed within individual lots, the engineer shall describe the coordination process between the developer and the builder in reference to the construction of bioretention facilities within individual lots. For properties with bioretention facilities and LID components within individual lots, the County will not issue the building occupancy permits until these facilities and any other LID or IMP components shown on the plan within the lots are constructed and approved. The LID storm water management plan shall include a hydrologic/hydraulic analysis of the downstream watercourse for all concentrated surface waters that will be discharged from a developed property.

The LID storm water management design plan shall contain charts, graphs, tables, photographs, narrative descriptions, explanations, and citations to supporting references as appropriate to communicate the information required by the Low-Impact Development Design Manuals. At a minimum, the final LID plan shall contain the following:

1) Comprehensive hydrologic and hydraulic design calculations, including all assumptions and criteria, for the pre-development and post-development conditions for the design storms. The Virginia SWM Handbook and appropriate portions of this manual shall be used as a reference for the design of bioretention facilities.
2) Delineated watersheds and micro-watershed areas.
3) Clearly defined design storms controlled by LID.
4) Compiled information on predevelopment conditions such as soils, slopes, land use, and imperviousness (connected and disconnected).
5) Evaluated predevelopment conditions and developed baseline measures.
6) Evaluated site planning alternatives, the locations of bioretention facilities if applicable and comparisons with baseline predevelopment conditions.
7) Evaluated Integrated Management Practices. The location of IMPs should be identified on the site. Compare with the baseline by accounting for the hydrologic mitigation from IMPs.
8) Evaluation whether supplemental measures are needed to control peak or volume of runoff.

3.11 Location of Bioretention Facilities

1) When siting bioretention facilities, septic areas must be avoided, unless the septic field utilizes a design specifically designed to accept surface water. Otherwise, maintain a 50-foot setback from the septic field to avoid cross contamination. It is preferable to locate bioretention facilities upstream of any septic field and to divert any overflow away from the field as well.
2) Bioretention areas should be placed at least 100 feet away from any source water location. Other restrictions may apply.
3) When siting bioretention on lots that will have a basement, the facility shall be a minimum of 25 feet set back down-gradient from the home

foundation. Where possible, the facility invert must be lower than the proposed basement floor elevation.

4) Set back from an outermost foundation footing where there is no basement shall be 5 feet or greater. Basement set backs apply whenever the structure has a basement. Exceptions may be acquired for planter box bioretention facilities located on industrial or commercially zoned property. For planter box bioretention facilities, waterproofing membranes (as a minimum) adjacent to the building are required.

5) Bioretention facilities shall not be installed across property lines. Additionally, whenever possible, bioretention should be sited on the same lot that generates the runoff. Every effort shall be made to situate bioretention facilities to allow for the full 10-foot easement spacing. Where this is not possible, the perimeter of the bioretention area shall be located at least two feet away from the property line. For weep garden designs, locate at least twenty feet away from any down-gradient property boundary or line.

6) In commercial or industrial settings, design for overflow is more critical. The paved surfaces flowing into the facilities that are incorporated in the parking lot landscaping islands can generate large quantities of runoff. Therefore, overland conveyance of overflow water and flow-through bioretention facility designs is discouraged.

7) When the discharge flow exceeds 3 cfs, the engineer shall evaluate the potential for erosion control to stabilize areas in and around bioretention facilities.

3.12 Easements for Bioretention Facilities

1) Storm drainage easements shall be recorded to identify the location of integrated management practices and bioretention facilities on lots or parcels. Some IMPs may not require an easement as identified by the County during plan review. The property owner shall not remove or structurally alter these facilities except in accordance with an approved stormwater management design plan.

2) For bioretention facilities, the easements shall correspond to the Water Quality Volume (WQV) ponding elevation plus a width of 10 feet around the facilities.

3) A 10-foot-wide access easement, clear of any obstructions, shall be provided for the maintenance of bioretention facilities except when the facility shares a minimum 10-foot-long boundary with a public right-of-way and drainage easement.

4) The Program Administrator may require provisions within the Home Owners' Association (HOA) document to facilitate the County's inspection of in-lot bioretention facilities. The homeowners will be required to conduct minor maintenance of bioretention and associated drainage areas leading into or out of bioretention areas. Also, specific language needs to be incorporated into HOA document that identifies an approach to encourage the homeowners to adhere to minor maintenance of bioretention facilities. The County may seek periodic assistance from HOA to notify homeowners of County's inspection dates for the bioretention facilities.

3.13 Bioretention Facility Construction Notes

1) Bioretention facility construction shall be completed after the site is stabilized.
2) When sediment traps are converted into bioretention facilities at the end of construction, the sediments must be removed and remaining surface scarified prior to constructing a bioretention facility. Wide-track equipment or light equipment with turf-type tires shall be used for the excavation to minimize unwanted compaction of on-site soils.
3) Bioretention facilities constructed prior to site stabilization shall be protected from sedimentation by the installation of silt fence around the facility. The sediment laden runoff shall be directed away from the facility where possible.
4) Stockpiled onsite topsoil to be used for bioretention planting soil shall consist of materials suitable for planting and shall be verified for an appropriate percolation rate by a geotechnical engineer. In addition to percolation rate, the planting soil for bioretention must be checked for pH, organic matter, magnesium, phosphorous, potassium and soluble salts. The standards are described under the state minimum standard for Bio-Retention in the Virginia SWM Handbook. The engineer shall pick representative samples from the stockpile to conduct these tests.
5) Planting soil medium must have an infiltration rate greater than 1.5 inches per hour. If native soil is not suitable, contractor shall install typical soil medium consisting of 20 percent top soil, 20 percent leaf compost, and 60 percent construction sand (coarse grained).
6) Installation of the planting soil medium shall be in 12-18 inches depths.
7) The gravel sump shall consist of 12" of double-washed #57 blue-stone (½- to 1½-inch diameter) overlaid with 6 inches of washed pea gravel.

8) When deemed necessary by the geotechnical engineer, planting soil shall be amended with construction sand (ASTM C-33 Concrete Sand) or leaf compost.

9) Mulch may be provided by onsite vegetation which has been shredded, stockpiled and aged for approximately 14 days. If green mulch is used, the contractor shall supplement green mulch with nitrogen fertilizer.

10) The developer shall warrant the plant materials for a minimum period of one year.

11) Perforated underdrain systems and filter fabric shall be installed on all bioretention basins and biofilters.

3.14 Maintenance Notes for Bioretention Facilities

In addition to the inclusion of a maintenance plan written in accordance with Appendix 10.20 or 10.21, the following notes shall be on the plan:

1) Mulch should be applied at least once a year uniformly for 2-3 inches total depth after application. Grass clippings are unsuitable as mulch.

2) The owner (property owner or HOA) is responsible for the periodic visual inspection, hand weeding, trimming, removal of trash and debris and recordkeeping, periodic monitoring, replacement of landscaping within the facility as needed, facility repair if the bioretention facility is located on individual lot. The HOA will be responsible for these items, if the bioretention facilities are located in common areas.

3.15 Bioretention Construction Sequencing

The following items shall be included in the construction notes on any plan that includes bioretention or biofilter:

1) Prior to the construction of bioretention or biofilter facilities a detailed narrative of construction sequencing and inspection requirements will need to be submitted for County approval.

2) Bioretention and biofilter facilities shall be protected from sedimentation during individual lot grading and house construction.

3) Bioretention area shall not be placed in service until the contributing drainage area has been stabilized and approved by the County.

3.16 BMP Efficiency

LID structural and non-structural practices can protect downstream waterways by reducing the post development pollutant loading through storm water runoff volume reduction and/or the filtering and settling of pollutants. Storm water volume reduction and the corresponding reduction in the peak rate of discharge can also serve to reduce water quality impacts associated with channel erosion.

The Virginia SWM handbook shall be referred to for the design of, filter strips, grassed swales and other environmentally sensitive BMPs.

Chapter 4

4 Low Impact Development

4.1 Introduction

Culpeper County encourages the use of low-impact development (LID) techniques to the maximum extent practicable complimented by the use of conventional stormwater management. Low-impact development stormwater management design (LID) approaches are fundamentally different from conventional design approaches and challenge traditional thinking regarding development standards, watershed protection, and public participation. LID combines fundamental hydrologic concepts with many of today's common stormwater strategies, practices and techniques to reshape development patterns in a way that maintains natural watershed hydrologic functions. The five principles of LID are:

1) Conservation of existing natural and topographic features;
2) Minimization of land clearing and impervious surfaces;
3) Maintenance or lengthening the pre-developed time of concentration;
4) Installation of integrated management practices (IMPs); and
5) Use of pollution prevention measures and practices.

The stormwater management goal for LID is to mimic predevelopment[1] runoff conditions for runoff volume, peak runoff rate, and frequency. To accomplish this, stormwater is managed in small landscape features located on each lot rather than in large facilities located at the outlet of drainage areas. Hydrologic functions such as infiltration, frequency and volume of discharges, and ground water recharge can be maintained in several ways. Examples are: the use of reduced impervious surfaces, functional grading, open channel sections, disconnection and utilization of runoff, and the use of bioretention/filtration landscape areas. This source control concept is quite different from conventional end-of-pipe treatment.

Since every aspect of site development affects the hydrologic response of the site, LID runoff control techniques also can address every aspect of site

[1] For purposes of this chapter, the term "predevelopment" means woods in good conditions.

development. There is a wide array of impact reduction and site design techniques that allow the site planner/engineer to create stormwater control mechanisms that function in a manner similar to natural control mechanisms. A fully successful LID design will mimic the watershed's water balance among volumes of runoff, infiltration, storage, ground water recharge, and evapotranspiration. With the LID approach, receiving waters experience little change in the volume, frequency, or quality of runoff.

The LID analysis and design approach focuses on the following hydrologic analysis and design components:

Runoff Volume Control: The predevelopment volume is maintained by a dual strategy of minimizing the site disturbance and then providing distributed retention areas that retain the runoff for the design storm event. A detailed CN evaluation is required to determine the required runoff volume. The storage volume determination, expressed as a percentage of the overall site area, is based on the design charts and nomographs included in the design manual Low Impact Development Hydrologic Analysis, U.S. EPA, Office of Water, EPA 841-B-00-002 dated June 1999, as amended.

Peak Runoff Rate Control: LID is designed to maintain the predevelopment peak runoff discharge rate for the selected design storm events. This is done by maintaining the predevelopment Tc and then using retention practices to control runoff volume and, if these retention practices are not sufficient to control the peak runoff rate, to use additional detention practices to control the peak runoff rate. Detention is temporary storage that releases excess runoff at a controlled rate. The use of retention and detention to control the peak runoff rate is defined as a hybrid approach.

Flow Frequency/Duration Control: Since LID is designed to emulate the predevelopment hydrologic regime through both volume and peak runoff rate controls, the flow frequency and duration for the post-development conditions will be almost identical to those for the predevelopment conditions. The impacts of development on the sediment and erosion and stream habitat potential at downstream reaches can then be minimized.

Water Quality Control: LID is designed to provide water quality treatment (WQv) using retention and filtration practices. The storage required for water quality control is compared to the storage required to control the increased runoff volume. The greater of the two volumes is the required retention storage.

Composite CN: The distribution of CN values in subareas across the site are assessed. LID design exploits opportunities to keep a low composite CN for a site by reducing impervious areas and preserving more trees and meadows. Consequently, this will lessen the amount of storage that would otherwise be required to maintain the predevelopment runoff volume.

Drainage Area Tc: While development typically decreases the Tc for a site, the predevelopment Tc can be restored by lengthening flow paths and reducing the length of piped and channelized runoff conveyance systems in favor of longer overland flow.

Retention: Retention storage can be provided for both volume and peak control, as well as for water quality control.

Detention: After other LID strategies are utilized, detention areas can be used as necessary to maintain the same peak runoff rate and/or prevent downstream flooding.

Integrated Management Practice (IMP) means low impact development micro-scale and distributed management techniques used to maintain the predevelopment site hydrology. IMPs are basically specific small LID controls that reduce runoff by integrating storm water controls throughout the site in small discrete units. IMPs focus on source controls, and may include, but are not limited to, bioretention facilities, dry wells, filter/buffer strips, grass swales, infiltration trenches and amended soils as specified in the Low-Impact Development Design Manuals. IMPs are distributed throughout the site to retain, detain, and filter the storm water runoff at a location closer to the point of origination.

4.1.1 Design Guides and Manuals for LID

The following documents and manuals may be used for the design of LID practices. Other available design documents may also be used as a reference, subject to approval of the Program Administrator.

1) The Virginia Storm Water Management Handbook, Volumes I and II.
2) Low-Impact Development Design Strategies: An Integrated Design Approach, United States Environmental Protection Agency, Office of Water, EPA 841-B-00-003 dated June1999 and subsequent modifications and updates thereof.
3) Low-Impact Development Hydrologic Analysis, United States Environmental Protection Agency, Office of Water, EPA 841-B-00-002 dated June 1999 and subsequent modifications and updates thereof.
4) LID Supplement to the Northern Virginia BMP Handbook (Under development at the time of this writing), NVRC, 2007.

4.1.2 LID Design

This Section applies only to the design of SWM facilities, such as, bioretention, filter strips and other LID practices. When a site is designed in combination with conventional SWM practices, this Section applies only to the design of LID practices.

1) Low impact development storm water management design plans developed consistent with the requirements of this section and which meet the requirements given in Chapter 3 of this manual for a Full LID Design shall be considered as satisfying the flood control, water quality, and water quantity performance criteria of the Culpeper County Stormwater Management Ordinance.
2) Planting for bioretention facilities in parking lot islands may be credited towards meeting the interior parking lot landscaping requirement in nonresidential areas. Applicants should reference the County's current landscaping requirements (Culpeper County Zoning Ordinance, Article 33 "*Landscaping and Screening*").

4.1.3 Hybrid Design

When the use of LID practices on a particular site is limited by physical constraints or other factors, or if the storm water requirements cannot be satisfied solely with the use of LID design techniques, then a "hybrid" design may be employed. A hybrid design employs both LID and conventional BMPs or detention practices (centralized BMPs) to meet storm water requirements. The result will be "partial" or "limited" LID design as defined in Section 3.6.1 of this manual. Such a design might conserve specific natural features and provide open space to the greatest extent possible, while detention practices or centralized BMPs are also implemented to provide peak rate or quantity control beyond the site-specific capabilities of the LID strategy.

Once LID site design strategies and practices have been evaluated and employed to the greatest extent practicable, and, where needed, additional SWM controls have been added, the engineer shall provide computations for the target performance of the design in satisfying requirements.

4.1.4 Bioretention Facility Design Considerations

1) Underlying soils at the bottom of bioretention facilities must have a minimum subsoil infiltration rates of 0.52 – 8.27 inches per hour (Virginia Stormwater Management Handbook Section 3.10, page 3.10-5); however, the Handbook also requires that a factor of two be applied to the minimum infiltration rate as a margin of safety against clogging over the

lifetime of the facility (Virginia Stormwater Management Handbook, Section 3.10, page 3.10-14). Therefore, the report must indicate a subsoil infiltration rate between 1.04 and 8.27 inches per hour. The under drainage system proposed shall be of approved material for such systems and have a hydraulic capacity greater than the planting soil infiltration rate. Under drainage system must be built with a cleanout well. Under drains shall be perforated with ½-inch openings, 6 inches center-to-center, in three longitudinal rows along the pipe.

2) The location of bedrock and seasonal high groundwater table shall not interfere with the function of bioretention facilities. The bottom of the bioretention facility should be located at least 24 inches above the observed high groundwater table.

3) A geotechnical engineer shall certify on the construction plan that the soils characteristics, depth to bedrock, and depth to water table meet the appropriate requirements.

4) Ponding water within bioretention facilities should be designed to infiltrate the runoff within a 4-6 hour period and to infiltrate completely within 24 hours.

5) Ponding depth within a bioretention facility shall be 12 inches with an underdrain. (See section 3.14 of this manual)

6) The drainage area to a bioretention facility shall be 1 acre or less.

7) The bioretention facility should be constructed in an offline configuration, unless appropriate measures are taken to divert excess runoff away from bioretention facility.

8) The bioretention facility shall have a non-erosive outfall.

9) When designing a landscaping plan for bioretention facilities, select plant materials that can tolerate extreme hydrologic changes, pollutant loading, and highly variable soil mixture conditions. (See plan recommendations in the Virginia Stormwater Management Handbook.)

10) Excess runoff shall be diverted away from bioretention facility by grading the elevation of the maximum surface ponding equivalent to the elevation at which runoff is discharging into the bioretention area.

11) A safe overland flow path for the excess runoff and use of erosion control techniques are required.

12) Sloped areas exceeding 20 percent shall not be used for locating bioretention facilities.

13) See Section 3.11 for other bioretention location requirements.

4.1.5 Construction Considerations

1) An interim sediment control facility may be situated in the same location as that of the bioretention facility, if precautions are taken not to hamper the effectiveness of bioretention facilities when they are constructed. In such situations, the proposed invert of bioretention facility must be at least 1 foot below the invert of the sediment control facility at that location. During the construction of the bioretention facility, the runoff must be directed away from the facility, and this shall be identified in the sequence of construction.
2) The engineer shall specify on the plan to “avoid excessive compaction that can hamper the performance of the proposed bioretention facility, around bioretention facilities”.
3) The plan should show that erosion controls around bioretention facilities are maintained with measures such as super silt fence until the drainage areas to these facilities are stabilized.
4) The notes on the final plan should indicate that a preconstruction meeting shall be held between the developer/contractor and the County’s site inspector to determine the inspection points needed.
5) The notes on the final plan should indicate that the contractor shall leave the tags on bioretention plantings to facilitate inspection.

4.2 LID Planning Techniques to Reduce the Post-development LID CN

Preservation of Pervious Soils: This approach includes site planning techniques such as minimizing the disturbance of soils—particularly in vegetated areas—that have high infiltration rates (Hydrologic Soil Groups [HGSs] A and B) and placement of infrastructure and impervious areas such as houses, roads, and buildings on more impermeable soils (Hydrologic Soil Groups C and D). Care must be taken when determining the suitability of soils for the proposed construction. Adequate geotechnical information is required for planning practices.

Preservation of Existing Natural Vegetation: Woods and other vegetated areas provide many opportunities for storage and infiltration of runoff. By maintaining the natural coverage to the greatest extent possible, the amount of storage needed for runoff management is minimized. Vegetated areas also can be used to provide surface roughness, thereby increasing the Tc. In addition, they function to filter out pollutants.

Minimization of Site Imperviousness: Reducing the amount of imperviousness on the site will have a significant impact on the amount of compensatory BMP storage required.

Disconnection of Site Imperviousness: Impervious areas are considered disconnected if they do not connect to a storm drain system or other impervious areas though direct or shallow concentrated flow. Directing runoff from impervious areas onto vegetated areas as sheet flow will increase infiltration, resulting in a direct reduction in runoff and corresponding storage volume requirements.

When the impervious areas constitute less than 30 percent of the total site, the percentage of the unconnected impervious areas within the watershed influences the calculation of the composite CN (SCS, 1986). By increasing the ratio of disconnected impervious areas to pervious areas on the site, the CN and the resultant runoff volume can be reduced.

Creation of Transition Zones: Transition zones are vegetated areas that can be used to store and infiltrate runoff from impervious areas before the runoff is discharged from the site. Providing these areas will not only affect the characteristics of site runoff, but also affect the computation of CN values.

4.3 LID Techniques to Maintain the Pre-development Time of Concentration

Proper use of the analytic tools for LID hydrologic design and analysis requires that the post-development time of concentration (Tc) be equal to the predevelopment Tc.

To maintain the Tc, LID designs use the following site planning techniques:

Maintaining or increasing the length of the predevelopment flow paths by dispersing and redirecting flows, generally through open swales and natural drainage patterns.

Increasing surface roughness (e.g., by reserving woodlands and using vegetated swales).

Detaining flow (e.g., in open swales and bioretention).

Minimizing site disturbance (avoiding the need for compaction and changes to existing vegetation).

Flattening grades in impacted areas.

Disconnecting impervious areas (e.g., by eliminating curb/gutter and redirecting downspouts).

- Connecting pervious and vegetated areas (e.g., by forestation and reforestation).
- Increasing the flow length
- Minimizing the amount of flow in closed channels and pipes
- Maximizing sheet flow regime. See Sheet Flow Table in Appendix ???
- Using a network of wider and flatter channels to avoid fast-moving channel flow.

4.4 Retention and Detention Storage

Small retention storage areas pond water on site for release through infiltration, evaporation, and transpiration, rather than through surface runoff during a storm event. Providing retention storage on site will reduce the post-development runoff volume and the peak runoff rate. Strategic use of retention storage to supplement the runoff reductions achieved by selective land cover choices allows the predevelopment runoff volume to be maintained. Retention devices for maintaining the predevelopment volume include, but are not limited to, the following:

- Infiltration trenches
- Retention ponds
- Rain barrels
- Bioretention (rain garden)
- Irrigation ponds
- Rooftop storage

In some cases, the amount of storage that maintains the predevelopment runoff volume will also be sufficient to maintain the predevelopment peak runoff rate. Where it is not, additional storage is required in the form of detention storage. LID stormwater management techniques for providing detention storage include, but are not limited to, the following:

- Swales with check dams, restricted drainage pipe, and inlet entrances
- Wider swales
- Rain barrel
- Rooftop storage
- Diversion structures

For bioretention computations, the following amounts shall be considered to be retention storage and the remainder shall be considered to be detention storage:

25% of water stored in the ponding area at the top of the bioretention area

50% of water stored in the mulch and engineered soil filter media above the crown of the underdrain system

100% of water stored in the facility below the crown of the underdrain system

4.5 Determination of Design Storm Event

A fundamental LID design objective for stormwater management is to keep runoff volumes and peak runoff rates for the developed site at or below the runoff volumes and peak runoff rates for the same site prior to development. These volumes and rates are associated with a specified design storm.

The criteria used to select the design storm for LID are based on the goal of maintaining the predevelopment hydrologic conditions for the site. The determination of the design storm begins with an evaluation of the predevelopment condition. The hydrologic approach of LID is to retain the same amount of rainfall within the development site as that retained by woods, in good condition, and then to gradually release the excess runoff as woodlands would release it. By doing so, we can emulate, to the greatest extent practical, the predevelopment hydrologic regime to protect watershed and natural habitats.

The CN for the predevelopment condition is to be determined based on the land cover being woods in good condition and the existing hydrologic soil group (HSG). The design storm is to be the greater of the rainfall at which direct runoff begins from a woods in good condition, with a modifying factor, or the 1-year 24-hour storm event.

4.6 LID Techniques

4.6.1 Overland Sheet Flow

The site should be graded to maximize the overland sheet flow distance and to minimize disturbance of woodland along the Tc flow path. This practice will increase travel times, thereby increasing the time of concentration. Consequently, the peak discharge rate will be decreased.

4.6.2 Flow Path

Whenever possible, increase flow path or travel distance of surface runoff to increase infiltration and travel time.

4.6.3 Site and Lot Slopes

When planning for final grades, flatten lot slopes to approach a minimum 1% to increase infiltration and travel time. For residential development, LID grading practices should be applied to lot areas located outside of the building pad area. The building pad area is a 10-foot perimeter around the building with a positive drainage of 5% slope. Lot areas outside the building pad perimeter should contain a positive slope of at least 1%. The engineer is responsible for ensuring that the slope of the lot does not cause flooding during the 100-year storm event (i.e., 1-foot vertical and 25-foot horizontal distance must be provided between the 100-year overflow path and the dwelling unit). Soil compaction in the lot area should be avoided to maximize the infiltration capacity of the soil. These infiltration areas can be hydraulically connected to impervious surfaces such as rooftops and driveways to decrease travel times for these areas.

4.6.4 Open Swales

Wherever possible, LID aims to use open drainage systems in lieu of more conventional storm drain systems. To alleviate flooding problems and reduce the need for conventional storm drain systems, vegetated or grassed open drainage systems should be provided as the primary means of conveying surface runoff between lots and along roadways. The two-year flow should produce velocities of 5 ft/s or less. Runoff should not travel over more than 3 lots or 300 feet.

4.6.5 Site and Lot Vegetation

Revegetate and/or plant graded areas to promote natural retention and increase travel time. Revegetating graded areas, planting, or preserving existing vegetation can reduce the peak discharge rate by creating added surface roughness as well as providing for additional retention and reducing the surface water runoff volume.

> Strategic clearing and grading practices are an effective method of reducing stormwater quantity and erosion impacts on downstream receiving waters and aquatic habitat. Minimizing clearing and grading within forested and densely vegetated areas on HSG A and B type soils is an efficient method of reducing changes to the CN.

Vegetated buffers are strips of vegetation, either natural or planted, around sensitive areas, such as water bodies, wetlands, or highly erodible soils. In addition to protecting sensitive areas, vegetated strips help to reduce stormwater runoff impacts by trapping sediment and sediment-bound pollutants, encouraging infiltration, and slowing and dispersing stormwater flows over a wide area.

Engineered landscaping is one method of mitigating the hydrologic impacts of clearing and grading. In some cases, the majority of the site will have to be cleared and graded, resulting in the loss of much woody vegetation and debris. A carefully designed landscaping plan can be used to reestablish some of the vegetative functions lost during this process. Heavily revegetated areas can improve sediment removal, infiltration, and community aesthetics.

Curb elimination addresses both quantity as well as water quality functions. When curbs are removed, site imperviousness is disconnected by allowing stormwater runoff, normally conveyed along the roadside and discharged directly into a storm drain system or receiving water body, to be dispersed to vegetated buffer areas or roadside swales. This process helps to minimize CN impacts, increase or maintain the Tc, and filter pollutants leaving a given site.

4.6.6 Bioretention

Bioretention BMPs are applicable as on-lot retention facilities that are designed to mimic pre-developed hydrologic regimes that naturally control hydrology through infiltration and evapotranspiration. They are especially suited to residential and commercial areas where additional landscaping can provide aesthetic benefits. It is recommended that bioretention areas incorporate vegetated filter strips as pretreatment devices. In commercial areas where space is limited, parking area sweeping is recommended as a pretreatment practice. See sections 3.12-3.16, 4.1.4 and 4.1.5 of this manual

4.6.7 Filter Strips

Filter strips are typically bands of close-growing vegetation, usually grass, planted between pollutant source areas and a downstream receiving waterbody. They also can be used as outlet of pretreatment devices for other stormwater control practices. For LID sites, a filter strip should be viewed as only one component in a stormwater management system. See section Appendix 11.6 of this manual

LID filter strips should be planted in combination with existing natural vegetation to meet the needed filter width. Usually the minimum width for grassed filter areas is 15 feet, while that of wooded areas is 35 feet.

Depending on specific site conditions, filter areas may be as wide as 150 feet. Filter strips function best when they are level in the direction of stormwater flow toward the receiving water. This orientation creates proper sheet flow through the strip, increasing infiltration and filtering of sediments and other organic solids. To prevent erosion channel formation, a level spreader should be situated along the top edge of the strip.

4.6.8 Grassed Swales

Grassed swales are earthen channels covered with a dense growth of hardy grass, such as Tall Fescue. Grassed swales are applicable alongside roads. Grassed swales are typically located at the outlets of road culverts, as conveyance between homes, and as highway medians.

LID swales may be designed with a curvilinear width to maximize storage volume for detention. For LID sites, side slopes outside a Rights-Of-Way may be 2:1. Longitudinal slope in swales must be minimized to a maximum of 2%.

4.6.9 Dry Wells and Rock Infiltration Trenches

Dry wells are underground rock storage chambers covered with a grass swale (See appendix 11.5) while rock infiltration trenches are small excavated trenches backfilled with stone. Dry wells and rock infiltration trenches function as infiltration systems used to control surfaced pollutants.

4.6.10 Rain Barrels

Rain barrels operate by retaining a predetermined volume of rooftop runoff. An overflow pipe provides some detention beyond the retention capacity of the rain barrel. Rain barrels also can be used to store runoff for later reuse in lawn and garden watering.

4.6.11 Level Spreaders

A level spreader is a device that is used to convert concentrated stormwater runoff into sheet flow and is constructed at the end of all storm sewers or channels that outfall into a buffer. The purpose of the level spreader is to introduce storm flows into the buffer at a slower rate and spread the flow over a larger area than would normally occur with a storm sewer outfall. This allows for more efficient use of the buffer by spreading the storm flow over a wider area of the buffer. Example details may be found in Appendix 11.33.

Level spreaders must be designed and constructed according to the following design criteria. All appropriate details must be included in the approved plans.

As indicated in the following table, either Design A or Design B (refer to sketches in Appendix 11.33) will be provided based upon the pipe size and 10-year storm discharge or, in the case of a channel, upon the 10-year storm discharge alone.

Pipe Diameter (inches)	10-Year Peak Discharge (cfs)									
	10	20	30	40	50	60	70	80	90	100
15	A	A								
18	A	A	A	A						
21		A	A	A	B					
24			A	A	B	B	B	B		
27			A	A	A	B	B	B	B	B
30				A	A	B	B	B	B	B
36						A	A	B	B	B
42									A	B

The sides and bottom of the plunge pool excavation shall be lined with filter fabric underlining and Class A1 rip rap in accordance with the Virginia Erosion and Sediment Control Handbook, Third Edition, 1992, State Minimum Standard and Specification Number 3.19.

The spreader weir section shall be constructed by excavating a trench to the depth and configuration shown, laying down hardware cloth and backfilling with VDOT No. 3 aggregate. The hardware cloth shall be galvanized steel, ½-inch mesh, 19 gauge. The hardware cloth shall be wrapped around the aggregate and timber as shown and the edges stapled to the top of the timber every 12 inches with ¾-inch galvanized steel staples.

The 6-inch by 6-inch timber shall be straight in the horizontal aspect and precisely level.

Special considerations shall be made where a cross slope exists in the area of construction and outfall and where there is a possibility that the storm water may flow around and bypass the spreader weir. An additional timber and aggregate weir section shall be constructed as shown to tie back into the existing grade.

A minimum of clearing and grading may be required downstream of the spreader weir section to ensure free overflow of storm water over the weir. Generally, all clearing and grading shall be kept to a minimum, but where required, the disturbed area shall be planted with sod in accordance with the Virginia Erosion and Sediment Control Handbook, Third Edition, 1992, State Minimum Standard and Specification Number 3.33. The sod shall be secured with netting and staples in accordance with Plate 3.33-2.

A subsurface drain shall be provided beneath the plunge pool. The drain shall be designed and constructed in accordance with the Virginia Erosion and Sediment Control Handbook, Third Edition, 1992, State Minimum Standard and Specification Number 3.28.

The required drainage easement must encompass the entire level spreader (dissipation section, plunge pool section, and spreader weir section) and provide an area 10 feet wide around the entire level spreader to provide for maintenance.

Chapter

5

5 Stormwater Management Concept Plans

5.1 Introduction

Chapter 11A of Culpeper County Code requires all preliminary plans of subdivision and major site development plans to include a Stormwater Management Concept Plan describing, in general, how stormwater runoff through and from the development will be conveyed and controlled. The purpose of a Stormwater Management Concept Plan is to assess the hydrologic and hydraulic conditions of the site before any development and to describe, in a general way, the stormwater management practices and features needed to meet applicable requirements and minimize the downstream impacts of the proposed development. A Stormwater Management Concept Plan is a complete and distinct plan intended to depict only the elements of a workable stormwater management concept for the proposed development.

The Stormwater Management Concept Plan is intended to be the basis for preparing a Stormwater Management Design Plan. It *should* be submitted and approved before significant resources are expended to prepare a Stormwater Management Design Plan and *must* be approved before a Stormwater Management Design Plan may be submitted. A copy of the approved Stormwater Management Concept Plan must be included with the final site plan or subdivision construction plan. A revised concept plan may be required if changes to a development proposal are made (i.e., a Preliminary Subdivision Plan is revised).

Construction details should not be included in a Stormwater Management Concept Plan. In fact, approval of the plan represents only an approval of the concept and not an approval of any construction detail. Approval of these is done with the Stormwater Management Design Plan.

Stormwater Management Concept plans for non-residential development should be prepared in accordance with this chapter and presented in five copies to the Department of Planning and Zoning. Concept plans for residential development should be prepared in accordance with this chapter and submitted to the Department of Planning and Zoning. Application and review fees will apply.

5.2 Stormwater Concept Plan Requirements

Complete design is not required in the Stormwater Management Concept Plan; however, sufficient analyses must be performed to show the plan is workable. The amount of analyses required will vary depending on the size and complexity of the site and the development.

A Stormwater Management Concept Plan contains five main components; a summary, a narrative, illustrative drawings, computations and LID checklist found in Appendix 11.3. The following paragraphs describe the information to be provided as a minimum for all sites.

5.3 Summary

This section of the Stormwater Management Concept Plan is a one-sheet synopsis of the project containing essential information about the project to be included in the plan set. Provide an information summary sheet with at least the following information included:

A vicinity map including north-orienting arrow

A summary table of all drainage outfalls, their contributing drainage areas, and the percentages of impervious cover proposed

A summary table of all the soil types to be found on the project site. Do not include types not found on the site. At a minimum, include the following information for each type:

a. Map Symbol
b. Soil Name
c. Hydric (Yes or No)
d. K factor (Topsoil and Subsoil)
e. Hydrologic Group
f. Depth to (Rock or Water)
g. Subsoil Permeability
h. Shrink Swell (L,M,H)
i. Flood Plain

Identification of the FEMA FIRM Panel Number(s) for the entire site

A statement as to whether any waiver requests apply or are being sought for the project and the nature of any such requests

A statement as to how low impact development site planning to the maximum extent practicable was utilized during development of the stormwater management concept and whether it resulted in a full, partial, or limited low impact development design concept for the site

A list of all other State and Federal permits expected to be required for the project

5.4 Narrative

This section of the Stormwater Management Concept Plan consists of a narrative description used to describe and relate the other components of the plan to each other. The narrative, not the drawings, is the centerpiece of the plan. It should address the features shown in the illustrative drawings provided. The narrative must include the following as a minimum:

A description of existing land use and drainage at the site, including natural drainage and any existing constructed drainage and stormwater management systems.

A description of wetlands on the site. Delineate these in the illustrative drawing section of the plan.

The number and a general description of conveyances at each point where shallow concentrated flow or channel flow crosses the project limits. Show these points in the illustrative drawing section of the plan.

A description of existing hydraulic conditions of the conveyances downstream of each point identified above.

A description of the proposed development and, in general, its impact upon the existing drainage as described above. In addition, include:

A description of the impacts upon wetlands presented by the proposed project. Illustrate these impacts, as appropriate, in the illustrative drawing section of the plan.

A description of the impacts upon one hundred-year floodplains areas presented by the proposed project. Illustrate these impacts, as appropriate, in the illustrative drawing portion of the plan.

A statement as to whether a full, partial, or limited LID design is proposed for the site.

A description of on-site drainage and stormwater management features proposed for required control of water quantity and water quality. Show locations of these in the illustrative drawing section of the plan. Provide initial design data and computations in the computations section of the plan to indicate that the proposed siting is likely to work (e.g., large enough area, great enough infiltration rate, etc.).

If off-site facilities will be relied upon to provide all or part of the required control, provide a description of those facilities and demonstrate on the plan that they will meet the requirements. Provide a drawing in the illustrative drawing section of the plan that shows the location of the off-site facility relative to the site and the conveyance features which transport runoff from the site to the facility. Provide data and computations to indicate the adequacy of these conveyance features to transport runoff from the site to the facility.

A description of conveyances downstream of each outfall including an initial determination as to whether the conveyance will be adequate.[1] Support this assessment in the calculations section of the plan.

A discussion of any local, state, or federal permits necessary for the proposed development.

For multi-phase projects, a schedule of facility construction indicating stormwater management and drainage requirements will be met as each phase of construction is completed.

A copy of any request for exception to stormwater management requirements being sought pursuant to Section 11A, Article II of the Culpeper County Code. See the Section Error! Reference source not found. for additional information.

A description of parties that will be responsible for maintenance of IMPs located on individual building lots and the legal documents that will be recorded to ensure such maintenance. See section 9.3 for additional information.

5.5 Illustrative Drawings

5.5.1 Existing Conditions

This section of the Stormwater Management Concept Plan consists of one or more drawing(s) used to illustrate conditions at the site at the start of the project. Provide one or more drawing(s) of the site at a scale of 1 inch to 200 feet or larger[2] including the following, as a minimum:

The property lines of the proposed site. If the property lines do not describe the project limits, show the project limits. Indicate in the narrative the authority required to work outside the property limits.

The boundaries of each soil type on the site. The scale of the soils map shall be the same as that used in the site plan or construction plan.

[1] An adequate channel is a natural or manmade surface channel which is capable of conveying runoff from the ten-year storm without overtopping its banks and from a two-year storm without eroding. A pipe or storm sewer is adequate if runoff from a ten-year storm is contained within the system.
[2] A scale larger than 1 inch to 200 feet would be, for example, 1 inch to 50 feet.

Label each area with soil name, hydrologic soil group, and whether or not the soil is hydric. All the types shown in the table in the summary section of the plan should be shown. (Soil borings may be required where infiltration facilities are proposed. If so, show boring locations, as well.)

Boundaries of wetlands found on the site.

Boundaries of the one hundred-year floodplains as shown on the most current FEMA Flood Insurance Rate Maps for Culpeper County.

A statement as to whether a Floodplain Study may be required. Note: If grading is anticipated within the 100-year floodplain or if construction is proposed which may significantly affect the location of the 100-year water surface elevation, a study will be required. (See Appendix 11.30 for additional information.)

Site topography with contours at least every five feet in elevation. Contours must be clearly labeled. Electronic versions of such topography generally available for site in Culpeper County from the Department of Planning and Zoning.

All points where shallow concentrated flow or channel flow crosses the project limits. Number or letter these for cross-reference.

Drainage areas to each point described above. Drainage area boundaries must indicate flow direction and must respect the underlying contours upon which they are drawn. Refer to each area using the number or letter given to its point of analysis. Label each area as to its size in acres. When drainage areas delineated in this way extend beyond the project boundaries, these off-site areas, and the underlying topography, must be shown.

The location of any existing water supply wells and septic systems.

DO NOT SHOW ANY PROPOSED DEVELOPMENT on drawings depicting existing conditions.

Drawings extracted from the most current FEMA Flood Insurance Rate Maps for Culpeper County with the project limits shown and with a reference to the map panel numbers.

5.5.2 Proposed Conditions

This section of the Stormwater Management Concept Plan consists of one or more drawing(s) of the site at a scale of 1 inch to 200 feet or larger[2] including the following, as a minimum:

The property lines of the proposed site as shown on drawings for existing conditions.

The boundaries of each soil type on the site as shown on drawings for existing conditions.

Boundaries of wetlands found on the site as shown on drawings for existing conditions. Show changes in boundaries caused by proposed development using different, more prominent line weight, style or shading.

Site topography as shown on drawings for existing conditions. Show proposed changes to existing contours using a different, more prominent line weight and style. Proposed changes should honor natural drainage divides to the maximum extent practicable. Contours must be clearly labeled.

All points where shallow concentrated flow or channel flow crosses the project limits. Label these with a number or letter for cross-reference. To honor natural drainage divides, these points should be the same as those for existing conditions to the maximum extent practicable.

Drainage areas to each point described above. Drainage area boundaries must indicate flow direction and must respect the underlying contours upon which they are drawn. Refer to each area using the number or letter given to it’s point of analysis. Label each area as to its size in acres. When drainage areas delineated in this way extend beyond the project boundaries, these off-site areas, and the underlying topography, must be shown.

Delineation of the location of the one hundred-year floodplain limits overlaid on a drawing of the site development.

Delineation of existing and proposed onsite drainage divides which use outfalls from the site as study points.

If private water or sewer systems are proposed, the location of proposed water supply wells and septic filter fields when infiltration facilities are proposed.

Locations and type of proposed stormwater management facilities and LID integrated management practices needed to provide required stormwater quantity and quality control including the location of proposed access to facilities.

5.6 Computations

This section of the Stormwater Management Concept Plan consists of data and computations which support the drainage and stormwater management elements proposed. Computations showing a completed design are not required; however, those computations shown must be complete and according to accepted engineering practices given in the design manuals listed in Chapter 1.

5.6.1 “Complete” Computations

In order to be “complete,” a computation must use an equation, methodology, or algorithm from the design manuals and must be reproducible and verifiable using information shown on the plan or drawn from a reference to the design manuals. All values used in a computation must be sourced to an acceptable reference (e.g., one of the design manuals) or to an illustration on the plan.

Output from computer programs may be used, but it must be clearly annotated and cross referenced so its relevance in the design is transparent and it must be a complete computation as defined here.

Consider the following example computation using the Rational Method for computing the existing two-year discharge at an outfall point from the site.

Two-year Discharge for DA-1 (existing conditions):

$$Q = CiA$$
$$Q = 0.72 \times 2.4 \text{ in/hr} \times 18.7 \text{ ac}$$
$$Q = 32.3 \text{ ft}^3/\text{s}$$

To be a “complete” computation for presentation in a Stormwater Management Concept Plan:

1) The Rational Method must be an appropriate method for this computation as defined in the Design Manuals
2) The 18.7 acres used as the value for A must be properly delineated on the illustrative drawing for existing conditions, must be labeled as DA-1, and must measure a scaled 18.7 acres.
3) The value of 0.72 used as the C-factor must be obviously appropriate, supported by a reference to one of the Design Manuals, or supported by a complete computation of composite C-factor. It must also be supported by existing cover information as shown on the illustrative drawing of existing conditions.
4) The value of 2.4 inches per hour used for rainfall intensity must be the result of a complete computation of time of concentration for DA-1 and use of the intensity-duration-frequency curve for Culpeper County shown in Section 2.4 of this manual or by using appropriate a and b constants as shown in Appendix 5A of the Virginia Stormwater Management Handbook.

5.6.2 Channel Adequacy

The purpose of investigating channel adequacy in the Stormwater Management Concept Plan is to document the condition of outfalls **prior to** development and to be sure they will be adequate when the project is complete. (See

For each new outfall shown on the drawings compute the two- and ten-year discharges and velocities as follows.

5.6.3 Stormwater Management Facilities

For each pond shown in the drawings, computations must show the anticipated performance (storage, discharges, etc.) requirements of the facility.

5.6.4 Low-Impact Development

Use of LID design to the maximum extent practicable is encouraged. For additional information on this topic, refer to Section 3.7 of this manual.

A LID Site Design Checklist and LID Calculations Worksheet (See Appendix 11.3) for the site is required as a minimum. When in support of a SWM Concept Plan, a single checklist and worksheet may be used which accounts for the entire site; however, times of concentration must be computed for each drainage area separately.

Infiltration devices must be planned at least 100 feet from wells and 50 feet from sanitary drain fields, preferably upstream.

5.7 Requests for Exception

Exceptions to the minimum stormwater management requirements of the Culpeper County Code[1] may be granted by the program administrator, upon receipt in writing from the applicant or property owner. Such requests are best made in conjunction with the Stormwater Management Concept Plan since they must be accompanied by descriptions, drawings, calculations, and other information necessary to evaluate the request—all of which are to be included in the Stormwater Management Concept Plan.

The request must be made in writing (separately from the Stormwater Management Concept Plan submission) and must be signed by the applicant

[1] Chapter 11A, Article II Culpeper County Zoning Ordinance

or property owner. Exceptions may be granted provided they are the minimum necessary to afford relief and are reasonable and appropriate. Conditions may be imposed upon an exception granted so the intent of the stormwater management provision of the Culpeper County Code is preserved. Economic hardship is not sufficient reason to grant an exception.

In order to grant an exception to the stormwater management provisions of the Culpeper County Code, the applicant must show at least one of the following:

That the proposed development is not likely to impair the attainment of the objectives of the stormwater management provisions of the Culpeper County Code.

That meeting the minimum on-site requirements is not feasible due to the natural or existing physical characteristics of the site.

That the location of the project in the watershed is such that on-site stormwater management will result in increased flows on the main stream. (This must be supported by hydrologic analysis or demonstration that the entire project site is less than 1 percent of the drainage area to a point of analysis on the property.)

That proposed development will cause no more than a ten-percent increase in the two-year and ten-year discharge rates AND the off-site receiving channel is adequate.[1]

That an *existing* off-site facility provides the required controls.

That an *existing* regional stormwater management facility provides the required controls and the property owner agrees to a pro-rata share contribution.

That a regional stormwater management facility has been identified for construction which will provide the required controls, AND the property owner agrees to construct all necessary interim stormwater management controls deemed necessary by the program administrator, AND the property owner agrees to a pro-rata share contribution.

Requests for exception must:

Specify the specific provision(s) of Culpeper County Code from which relief is being sought.

Describe the project condition (other than economic) that makes compliance with the provision(s) impossible or impracticable.

[1] An adequate channel is a natural or manmade surface channel which is capable of conveying runoff from the ten-year storm without overtopping its banks and from a two-year storm without eroding. A pipe or storm sewer is adequate if runoff from a ten-year storm is contained within the system.

Stipulate which one or more of the condition(s) necessary to grant the waiver is true for the exception being requested.

Demonstrate with descriptions, drawings, calculations, and other information that the condition(s) necessary to grant the waiver exists in fact.

Copies of any approved requests for exception which apply or which are being sought must be included in the Stormwater Management Concept Plan submission.

5.8 Concept Plan Submittal Checklist

STORMWATER MANAGEMENT CONCEPT PLAN
November 2008

Complete design is not required in the Stormwater Management Concept Plan; however, sufficient analysis must be performed to show the plan is workable. The amount of analyses required will vary depending on the size and complexity of the site and the development.

A Stormwater Management Concept Plan contains five main components; a summary, a narrative, illustrative drawings, computations, and LID Checklist.

I. ___ 5.3 Summary (Page 38)
- a. ___ Vicinity Map with North-Arrow
- b. ___ Summary table of all drainage outfalls, contributing areas, and percent impervious cover
- c. ___ Summary table of all Soil Types
- d. ___ Identification of FEMA FIRM Panel Number for the site
- e. ___ Waiver/Exception statement if applicable
- f. ___ Statement of LID implementation (FULL, PARTIAL, OR LIMITED, section 3.6 on page 13)
- g. ___ List of all State and Federal permits expected

II. ___ 5.4 Plan Narrative (Page 39)
- a. ___ Natural Resource Assessment Narrative (Appendix 11.3)

i. ___ Describe existing land use and drainage, include natural and manmade drainage features
ii. ___ Describe wetlands and surface waters on site
iii. ___ The number and general description of conveyances at each point where shallow concentrated flow or channel flow crosses project limits.
iv. ___ Describe existing hydraulic conditions of the conveyances downstream of each point.

b. ___ General project description and impact on existing drainage
c. ___ Describe on-site drainage and permanent stormwater management facilities proposed for required water quantity and water quality.
d. ___ Describe off-site facilities used to meet the required runoff control
e. ___ Describe downstream conveyance and include an initial adequate channel analysis.
f. ___ Describe parties responsible for maintenance of BMPs and legal documents, see section 9.3.

III. ___ 5.5 Illustrative Drawings (Page 40)

a. ___ Provide a Pre-development and Post-development maps
b. ___ Show property line and project limits
c. Natural Resource Assessment Maps
  i. ___ Soils
  ii. ___ Vegetation (trees)
  iii. ___ Wetland and Surface Waters delineation
  iv. ___ Drainage with elevation contours
  v. ___ Critical Slopes
  vi. ___ Existing man-made drainage structures (Ditch or Culvert)
d. ___ 100-year floodplains from FEMA Flood Insurance Rate Map.
e. ___ A statement of floodplain impacts and need for flood plain study if applicable.
f. ___ Show Stream Buffers and Stormwater Easements where applicable
g. ___ Show all points where shallow concentrated or channel flow crosses project limits.
h. ___ Location of existing and proposed water supply wells and septic systems.
i. ___ Location and Types of LID BMPs

IV. ___ 5.6 Computations (Page 42)

a. ___ All values used must be sourced to an acceptable reference or illustration on the site plan
b. ___ Channel Adequacy, compute two-, ten-year discharge and velocity
c. ___ Each BMP show anticipated performance (storage, discharge, etc.)
d. ___ LID Calculation Worksheet (Appendix 11.3)

V. ___ LID Checklist (Appendix 11.3)

Chapter 6

6 Stormwater Management Design Plans

6.1 Introduction

A Stormwater Management Design Plan is a set of drawings and supporting documents provided in conjunction with the construction plan or final site plan. It comprises all of the information and specifications for the systems and structures to be used to convey and control stormwater runoff. It is complete, separate, and distinct from other elements of the construction plan and is intended only to depict a workable stormwater management design.

This chapter presents an overview of submission requirements for technical review and approval of Stormwater Management Design Plans. The Stormwater Management Design Manuals and other guidance documents listed in Chapter 1 of this manual should be consulted for details of these requirements. Requirements for stormwater management facilities other than storm drainage, retention and detention basins and bioretention and biofilter facilities are not summarized in this chapter. The designer must provide all the information needed to support the stormwater management design. The Design and Plan Review Checklists provided in the Chapter 3 Appendix of the Virginia Stormwater Management Handbook should be utilized to ensure all the necessary information is included.

6.2 Stormwater Management Design Plan Requirements

All Stormwater Management Design Plans must include, as a minimum, the information described in this section. Information must be shown clearly and unambiguously. Consider scale, line weight, line style, typeface size, shading, information crowding, and other such factors when preparing sheets. Information which is unclear, ambiguous, or overcrowded may be rejected as though it were not presented in the plan.

The following is the suggested contents and order of a Stormwater Management Design Plan:

1) A copy of the approved Stormwater Management Concept Plan for the project
2) Summary Sheet (including Project Description)
3) Overall Development Plan
4) Drainage Area Map(s)
5) Plan View(s) of proposed drainage and stormwater management
6) Profile View(s) of proposed drainage and stormwater management with computations
7) Construction details for non-standard drainage structures and stormwater management facilities
8) Erosion and Sediment Control Plan
9) Maintenance plan for stormwater management facilities and recommendations from geotechnical study report
10) Calculations

6.3 Summary Sheet

Provide an information summary sheet with at least the following information included as a minimum:

General information including project name, plan preparer, date of drawing, legend, graphic scale and north arrow

A narrative description of project and proposed design indicating how site drainage, water quality, and water quantity requirements are addressed in the stormwater management design. Highlight and describe areas where the SWM Design Plan differs or departs from the approved SWM Concept Plan.

6.4 Overall Development Plan

Provide a drawing of the overall development at a scale to contain the drawing on a single sheet. If the scale required is smaller than 1 inch to 50 feet, include additional sheets at a scale of 1 inch to 50 feet or larger showing the entire development. Include the property line of the development project. If for any reason, property lines do not accurately reflect the limits of the project, provide a line indicating those limits and documentation of authority to develop. Include a project schedule with sequence of construction. If this is included in the erosion and sediment control narrative, reference it in this section of the plan.

6.5 Drainage Map

The Stormwater Management Design Plan must include a map showing onsite and offsite drainage (the area upstream of the point of analysis within the same watershed) areas at a scale of 1 inch to 200 feet or larger. A smaller scale may be used when a large offsite area is involved. Scale should be appropriate to size of area. The following items are required as a minimum:

Property Line of Development Project. If for any reason, property lines do not accurately reflect the limits of the project, a line indicating those limits and documentation of authority to develop.

Existing Contours. Show the existing contours of the site at one- or two-foot intervals. Contours must be clearly labeled. 10 foot minimum.

Final Contours. Show changes to the existing contours using different line weight and style. Contours must be clearly labeled. 2 foot minimum.

Stormwater Outfalls. Indicate the points along the property line or project limits where stormwater runoff leaves the site.

Land Uses. Delineate existing and proposed land uses. Indicate the size of each area delineated in acres.

Soils. Show the boundaries of different soil types.

Drainage Areas. Delineate the drainage areas to the stormwater outfalls as indicated above. Indicate the size of each drainage area in acres. Label drainage areas for cross-referencing computations.

Existing and Proposed Drainage. Show stormwater outfalls and drainage areas for both existing and proposed conditions.

Drainage to Structures. Delineate the drainage areas to all existing and proposed drainage structures and stormwater management facilities.

Structure Labels. Provide structure numbers and labels for drainage system and stormwater management facility structures for cross-referencing computations

Times of Concentration. Show time of concentration flow paths for both existing and proposed drainage areas. Identify sheet flow, shallow concentrated flow, and channel flow segments for each flow path.

North Indicating Arrow. Provide an arrow indicating north and a graphic scale for each plan view included. If more than one plan view is shown on a single sheet of the plan set, include a north-indicating arrow and graphic scale for each.

6.6 Plan View

The stormwater management design must be illustrated in plan view(s) showing, as a minimum, the following information:

6.6.1 General

The property line of development project.

Name of adjacent property owner(s) and tax map parcel number(s).

Existing and proposed contours at one- or two-foot contour intervals.

Floodplains as shown on the most recent FEMA map.

The extent of wetlands.

Proposed buffers and conservation easements.

Soils information with hydrologic soil groups identified.

6.6.2 Storm Drainage Systems

Structure numbers.

Existing and proposed storm drainage and access easements.

Drainage pipes showing diameter, type and class.

Proposed roads showing high and low points and throat elevations of inlets.

Grading and spot elevations at outflows, headwalls, and over storm sewer systems.

Path of overland relief.

House locations where critical to assess adequacy of drainage.

The one hundred-year headwater pool at proposed culverts and storm drainage structures except driveway culverts.

The location of existing and proposed utilities.

Spot elevations showing the limits of the 100-year flood elevations resulting from blocked conditions.

Location(s) of required easement(s).

6.6.3 Stormwater Management Facilities (Detention/Retention)

The location and topography of the facility including impoundment, embankment(s), primary outlet structure elements.

The location and topography of all emergency spillways and outlet channels of the design.

Outlet protection and outfall channel details.

The location of soil borings made to support soils studies and geotechnical recommendations.

Delineation of one-, two-, ten-, and one hundred-year pools in detention and retention basins.

Delineation of the "normal pool" in retention basins.

Dry and wet weather flow paths in extended detention basins and stormwater wetlands which eliminate short circuiting.

Maintenance access for stormwater management facilities.

Location of required easements.

6.6.4 Bioretention and Biofilter Facilities

The location and topography of the facility including impoundment, embankment(s), underdrains, and primary outlet structure elements. Topography shall be at no greater than 1-foot intervals; 6-inch contours are better.

The location and topography of any emergency spillways or outlet channels of the design.

The location of soil borings made to support soils studies and geotechnical recommendations.

Delineation of the storage pool.

Location and type of plantings.

Maintenance access for stormwater management facilities.

Location of required easements.

6.7 Profile View

The stormwater management design must be illustrated in profile view(s) showing, as a minimum, the following information:

6.7.1 Storm Drainage Systems

Structure numbers

Size, type, class, length and slope of pipe or structure

Existing ground and proposed grade at channel centerline and both banks

Ten-year velocity and discharge, friction slope

Ten- and one hundred-year water surface elevations at entrances and outfalls

Outfall protection detail

Pipe inlets and inverts

Utility crossings and inverts

Typical cross section(s) for stormwater conveyance channels and storm drain outfalls

Bottom width, height, existing ground side slope and type of stabilization

Ten-year water surface elevation

6.7.2 Stormwater Management Facilities

Principal spillway profile and associated details

Existing ground and proposed grade

Dam side slopes

Top width

Core trench

Materials

Bottom width, side slopes, depth

Riser Structure (detail required) including materials, structure and orifice dimensions

Trash rack (detail as required for construction)

Anti-vortex (detail as required for construction)

Structure footing

Barrel including materials, bedding detail, location of phreatic line (for retention ponds), seepage control elements

Outfall protection with section detail as required for construction showing rip-rap size, bottom width, side slope, filter cloth, etc.

Elevations of top of dam (constructed and settled), crest of emergency spillway, crest of riser structure, and inverts of orifices and weirs

Water quality, one-, two-, ten-, and one hundred-year pool elevations

Barrel with inlet and outlet invert, size and slope

6.7.3 Bioretention and Biofilter Facilities

The following must be shown to scale in profile, as a minimum;

Elevation of excavation bottom.

Elevations, materials of all backfill materials, including mulch layer

Underdrain pipe size, type, and perforation pattern

Weir and orifice invert elevations

Weir length and width, and orifice diameter

Observation / cleanout pipe

Inlet details (curb cut, or other)

6.8 Construction Details

In addition to the other information required to be shown specifically in plan or profile views, the following information must be provided.

Design detail when not using standard structure

A structure and pipe schedule including types of structures and standard details and location, size, type, and length of pipes

Geotechnical report prepared by a licensed geotechnical engineer including soil boring locations and logs.

A completed checklist for stormwater detention ponds (see Virginia Stormwater Management Handbook checklists)

Site preparation notes

Sequence of construction

Dam construction notes

Concrete construction notes

Rip-rap and slope protection notes

Site stabilization notes

Schedule of required inspections

Person/Entity responsible for oversight

6.9 Erosion and Sediment Control Plan

The Stormwater Management Design Plan must include a complete Erosion and Sediment Control Plan in accordance with the suggestions and requirements in Chapter 6 of the Virginia Erosion and Sediment Control Handbook and Chapter 8 of the Culpeper County Code. Information required elsewhere (soils information, for example) need not be duplicated in the Erosion and Sediment Control portion of the Stormwater Management Design Plan.

Plan preparers should keep in mind that a complete and comprehensive narrative including multi-phasing and sequence of construction is essential.

6.10 Maintenance Plan for Stormwater Management Facilities

Maintenance plans must be provided for all stormwater management facilities and integrated management practices. These plans must be included in the stormwater management design plan. Sample plans are located in appendices 110.169 through 10.23 to this manual which may serve as a starting point for preparation of maintenance plans for the most common facility types.

Plan preparers should view the maintenance plan as an “owner and operator manual” for the stormwater management design. Therefore, it should contain physical and functional descriptions of stormwater management features so the owner can identify the elements, appreciate their importance, and understand how they are intended to work.

6.11 Calculations

This section of the Stormwater Management Design Plan consists of data and computations which support the drainage and stormwater management elements of the design. Computations showing a completed design according to accepted engineering practices given in the design manuals listed in Chapter 1 are required.

Computations must be provided which support all the hydrologic and hydraulic elements of the design. As a minimum:

A completed LID Site Design Checklist and LID Calculations Worksheet for each drainage area in which a full or partial LID design is to be utilized.

Hydrologic and hydraulic computations for storm drains.

Hydraulic grade line computations for storm drain systems.

Hydrologic, hydraulic, and water quality computations for stormwater management facilities.

Design computations as required by design guidelines being followed, *e.g.* buoyancy computations for riser structures.

6.11.1 "Complete" Computations

In order to be "complete," a computation must use an equation, methodology, or algorithm from the design manuals and must be reproducible and verifiable using information shown on the plan or drawn from a reference to the design manuals. All values used in a computation must be sourced to an acceptable reference (e.g., one of the design manuals) or to an illustration on the plan.

Output from computer programs may be used, but it must be clearly annotated and cross referenced so its relevance in the design is transparent and it must be a complete computation as defined here.

Consider the following example computation using the Rational Method for computing the existing two-year discharge at an outfall point from the site.

Two-year Discharge for DA-1 (existing conditions):

$$Q = CiA$$

$$Q = 0.72 \times 2.4 \text{ in/hr} \times 18.7 \text{ ac}$$

$$Q = 32.3 \text{ ft}^3\text{/s}$$

To be a "complete" computation for presentation in a Stormwater Management Concept Plan:

1) The Rational Method must be an appropriate method for this computation as defined in the Design Manuals

2) The 18.7 acres used as the value for A must be properly delineated on the illustrative drawing for existing conditions, must be labeled as DA-1, and must measure a scaled 18.7 acres.

3) The value of 0.72 used as the C-factor must be obviously appropriate, supported by a reference to one of the Design Manuals, or supported by a

complete computation of composite C-factor. It must also be supported by existing cover information as shown on the illustrative drawing of existing conditions.

4) The value of 2.4 inches per hour used for rainfall intensity must be the result of a complete computation of time of concentration for DA-1 and use of the intensity-duration-frequency curve for Culpeper County shown in this manual. See Appendix ???

6.11.2 Channel Adequacy

The purpose of investigating channel adequacy in the Stormwater Management Design Plan is to document the condition of outfalls **upon completion** of the proposed development to ensure they will be adequate when the project is complete.

1. Storm sewer pipes chould discharge into a defined channel if possible.
2. Reduce storm sewer pipe discharges to broad dry swales wherever possible.
3. Where a defined channel does not exist, use infiltration practices or flow dispersion techniques to the maximum extent possible.
4. For each outfall shown on the drawings of existing and proposed conditions, compute the two- and ten-year discharges and summarize impacts using DCR's method from Technical Bulletin #1 for channel analysis:
    a. Minimum of 3 surveyed cross-sections at a minimum spacing of 50 feet along the channel downstream of discharge point.
    b. Channel top of bank should be well defined and identifiable by field parameters such as flattening or change in bank slope or other indicators of frequent bankfull flows (sandy deposits or debris deposits).
    c. When top of bank is not obvious, a hydrologic analysis of the contributing drainage area and the corresponding 2-year undeveloped peak discharge may be used to define the channel cross-sectional area.
    d. Analyze channel lining and determine permissible velocity.
    e. Determine average longitudinal slope of channel.
    f. Hydraulic grade line calculations for any existing or proposed pipe system to verify flow containment of the 10-year storm event.
5. Note unstable channel segments and pictures may be provided.

6. Supplemental channel analysis may be provided or requested based on the Resource Assessment.

6.11.3 Stormwater Management Facilities

For each pond shown in the drawings, computations must show the performance (storage, discharges, etc.) required of the facility. Computations must be provided to verify elevation-discharge-storage tables for stormwater management facilities.

Chapter
7

7 Easements

7.1 Stormwater Drainage Systems

Within any land development project, stormwater drainage easements must be provided for all improved stormwater drainage systems. Storm drainage easements must be provided for existing or improved swales and channels receiving runoff from more than two lots.

Stormwater drainage easements must be extended to upstream property lines to permit future development to have reasonable access for connections to on-site drainage ways or drainage systems.

Stormwater drainage easements must be shown on the record plat and on the Stormwater Management Design Plan. New storm drainage easements shown on lot grading plans must be properly recorded.

Adequate access easements must be provided to any storm drainage easement.

7.2 Easement Width Requirements

7.2.1 Open Systems

Easements must be provided in accordance with the following table:

Top Width Channel of Channel (ft)	Minimum Easement Width (ft)
Less than 2	15
2 – 5	20
5 -10	25
Greater than 10	15 ft greater than top width of channel

A minimum of 10 feet of the above easement must be on one side of the channel.

7.2.2 Storm Sewers

Diameter of Pipe (in)	Minimum Easement Width (ft)
15 - 18	15
21 -33	20
36 - 48	25
54 - 72	30

All storm sewer pipes must be located in the middle one-third of the easement.

Beginning at 10 feet in depth, an additional five feet of easement must be required for each five foot increment of additional depth.

For dual pipes each less than or equal to 60 inches in diameter, the easement width must be increased by 5 feet. For dual pipes each greater than 60 inches in diameter, the easement width must be increased by 10 feet.

7.2.3 Stormwater Management Facilities

Storm drainage easements must be provided for all stormwater management facilities located within any land development project.

Storm drainage easements must be shown on the record plat and on the Stormwater Management Design Plan.

Easements for conventional retention, detention and infiltration basins must encompass pond area, embankment and outlet structures. The easement must be located a minimum of 25 feet horizontal distance outside of the one hundred-year pool area.

Easements for bioretention and biofilter facilities must encompass pond area and outlet structures.

Easements for underground storage facilities are required. The Program Administrator must determine easement size for pipes larger than 72 inches and for underground storage chambers.

A minimum 12-foot-wide access road with a maximum grade of 12% and accompanying access easement should be provided to allow vehicular access to both the outlet structure area and at least one side of the detention/retention basin. The road's surface material should be selected to support the anticipated frequency of use and the anticipated vehicular load without excessive erosion or damage. [13]Refer to Appendix 10.24.

[13] As a minimum, 4 inches of aggregate 21A shall be used.

7.2.4 Integrated Management Facilities

For development projects utilizing a LID design, storm drainage easements must be recorded as follows:

For IMPs located adjacent to public rights-of-way, the drainage easement must contain the facility and share a border with the right-of-way.

For IMPs located in common areas, easements must be located in the same manner as conventional SWM ponds.

For IMPs located on private lots, easements must be recorded to identify the location of IMPs.

Refer to Section 3.12 for more information regarding easements for bioretention facilities.

7.2.5 Access Easements

Access to stormwater management facilities and integrated management practices from public routes must be provided. These must be within access easements with minimum width of 10 feet. See Appendix 10.24 for illustration of requirements for ponds.

Chapter
8

8 Construction Inspections and As-Built Plans

8.1 Inspections

Construction inspections are required to ensure that stormwater management facilities and stormwater drainage systems are being constructed in accordance with the approved design plan. The developer is responsible for maintaining a written report or log containing dates and times of inspections, inspection reports and comments concerning verbal communications relating to the project throughout the course of construction.

8.2 Geotechnical Inspections

Geotechnical inspections under the direction of a geotechnical engineer shall be performed during the construction of a stormwater management facility.

8.2.1 Detention and Retention Basins

No fill may be placed in a core (cutoff, key) trench until the geotechnical engineer has inspected the trench and approved the location, shape and depth of the trench. Trenches shall normally be installed under the centerline of the dam. The exception is where the trench is to be placed under the upstream toe of the dam and tied in with a clay lining. Variations from the approved design plan shall be discussed with Culpeper County's Program Administrator before any variation is implemented and may require submission of a revised design plan.

The geotechnical engineer shall inspect all fill placed in the core trench and in the dam. The geotechnical engineer shall ensure that no objectionable materials are placed in the trench or in the dam. In zoned dams (Define), the geotechnical engineer shall ensure that the gradation of adjacent zones is in accordance with criteria set forth in Design of Small Dams (US Government Printing Office). The geotechnical engineer shall ensure that fill materials under the barrel and the riser are compacted in accordance with the design plan .

The geotechnical engineer shall ensure use of proper compaction methods for all materials placed in the trench and in the dam.

The geotechnical engineer will also inspect special features such as toe and blanket drain. Sand and gravel used in drains shall be encapsulated in filter fabric; such encapsulation and the type of fabric will be verified by the geotechnical engineer. The VDOT number or size and gradation of drainage materials and compaction by a vibratory compactor will also be verified.

8.2.2 Geotechnical Inspection Reports

8.2.2.1 Detention and Retention Basins

After completion of the required inspections and associated tests and analyses, a report shall be prepared by a licensed geotechnical engineer for all retention basins. A report shall be prepared for all detention basins with greater than five feet dam height. A written report is not required for small structures; however, the inspections shall still be performed in accordance with this chapter. If the report indicates that changes to design are needed, it shall be submitted for review at such time along with a revised design plan. Otherwise, the report shall be submitted with the as-built plans. Each report shall include:

Core trench depths and types of materials encountered. The description shall include the classification under the Universal Soil Classification System (USCS) in addition to a geologic description.

Description of fill materials used, including USCS classes and presence of mica schist. The report shall verify that no objectionable materials (including OH and OL soil materials, topsoil, organic matter, stones larger than six inches, frozen soil) were placed in the dam or in the core trench. The report shall verify that fill material under the pond barrel and the riser was compacted to at least 95%. The report shall verify the compaction of the remainder of the fill, including percentage of compaction and methods used to obtain the compaction.

The report shall include details of special features such as toe/blanket drains, filter materials, etc.

8.2.2.2 Infiltration Facilities, Underground Detention Storage Facilities, Integrated Management Practices and Other BMPs

An appropriate geotechnical inspection report shall be prepared and submitted by a licensed geotechnical engineer. Each report shall include:

a. Soil property description of the underlining natural soil of any excavated trench. Soil properties should include Bulk Density, Saturated Hydraulic Conductivity, presences of restrictive layers (i.e. Bedrock or Water Table) and pH. Linear Extensibility and Shrink-Swell Potential evaluation is needed for practices with underdrain systems.

b. Description and certification of the soil medium. Including sand/clay/organic content, Bulk Density, Saturated Hydraulic Conductivity, and pH.

8.2.3 County Inspections

The contractor must notify County Staff at least 24 hours in advance of starting work on each of the following:

8.2.3.1 Stormwater Conveyance Channels

Completion of excavation

Construction of check dams (vegetated swales)

Final stabilization

8.2.3.2 Storm Sewers and Culverts

At beginning of excavation

During pipe laying and backfill

Placement of concrete structures

Prior to finalization; structure must be cleaned

8.2.3.3 Detention and Retention Facilities

Core trench fully excavated and no fill in place

Core trench backfill

Bedding and installation of barrel

Installation of toe drains, etc.

Pouring of concrete for riser base

Construction of embankment

Final stabilization

8.2.3.4 Underground Detention Systems

Installation and backfill of pipe

Placement of concrete

Prior to finalization

8.2.3.5 Bioretention, Biofilter, and Infiltration Facilities

Completion of excavation

Construction of embankment (infiltration basin)

Placement of concrete

Installation of filter fabric

Placement of each layer of backfill

Installation of final cover and plantings

Final stabilization

8.2.3.6 Porous Pavement Facilities

Completion of sub-grade section

Placement of aggregate base course

Placement of the aggregate filter course

Placement of porous asphalt concrete surface course to ensure laying temperatures and compaction

Periodic inspections of the stormwater management system construction must be conducted by County staff. However, the developer must be responsible for performing the required inspections in accordance with Sections 8.1 and 8.2 and providing the professional certification of construction in accordance with Section 8.4.

8.3 As-Built Requirements

An as-built plan is required for all stormwater management structures (i.e., drainage systems, stormwater management facilities, filters, and infiltration facilities).

As-built plans must be submitted within 60 days after completion of the structure.

As-built plans must be approved by the Zoning Administrator prior to the release of the security.

As-built plans must provide at a minimum all of the information on the as-built plan checklists in the Virginia Stormwater Management Handbook and this manual (Appendix 10-18). As-built plans must consist of a copy of the approved construction plans with as-built elevations and dimensions boxed in. Design elevations and dimensions must not be changed.

If a structure is built differently from the Stormwater Management Design Plan (see acceptable construction requirements on checklist), the Zoning Administrator must be contacted to determine whether the variation is acceptable or modifications to the structure will be required. The designer must provide hydrologic and hydraulic computations to verify that the structure functions as intended.

8.4 Certification

Each as-built plan must have a certification statement by a professional licensed in Virginia to perform such work. The certification statement is as follows:

> I (submitting professional's name) certify that, to the best of my knowledge, this as-built plan represents the actual condition of the structure(s) and conforms with the approved design plan except as shown and that all aspects of the structure(s) were constructed in accordance with the approved design plans and the Stormwater Management Design Manuals.

The County may accept separate certifications for various aspects of the project provided that these certifications, when combined, cover all as-built information and construction on the site.

Chapter
9

9 Maintenance

9.1 Maintenance Agreements

A maintenance agreement must be entered into between the landowner and the Board of Supervisors for all proposed private stormwater management facilities. The maintenance agreement must be executed and recorded in County land records prior to approval of the Stormwater Management Design Plan. The agreement must obligate the landowner to provide maintenance to ensure proper performance of the facility in accordance with an approved maintenance plan. A maintenance agreement is not required for stormwater drainage systems.

For integrated management practices located on individual residential lots in residential developments, the developer shall draft and cause to be placed into the land records for the property a covenant which obligates owners of lots containing IMPs to provide maintenance and access for maintenance.

A sample copy of the maintenance agreement is at Appendix 10.15.

9.2 Maintenance Plans

Property owners or organizations of property owners will ultimately be responsible for maintenance of stormwater management systems. To fulfill this responsibility, they must understand what the system consists of and how to properly operate, inspect, and maintain it. As the designer, the engineer must document the operation, inspection, and maintenance requirements for the system in terms owners can understand and carry out.

A maintenance plan must be prepared for all stormwater management systems. The plan must describe the system and list facilities and items to be maintained. The plan must be tailored to the specific structure for which it applies.

The maintenance plan must be prepared in conjunction with the SWM Design Plan and a copy of the plan must be attached to the maintenance agreement. The maintenance plan must address applicable State regulations (e.g., Virginia Dam Safety Act, etc.). Plans must be prepared to address maintenance as outlined in the applicable sections of the Virginia Stormwater Management Handbook.

The maintenance plan must specify a schedule of inspections in accordance with the operation and maintenance inspection checklists provided in the Virginia Stormwater Management Handbook. For facilities designed to accumulate sediment, the maintenance plan must provide a schedule for sediment cleanout. Sediment accumulation should be removed often enough to ensure that storage available below any primary outlet is not less than 80 percent of the designed BMP storage.

The maintenance plan must specify that any modifications to the structure must be approved by the Program Administrator before such work is undertaken.

9.3 Maintenance of LID Designs

LID sites shall require legal information and instruments to ensure that the facilities are properly maintained. These may include easements, maintenance agreements, and homeowners' association (HOA) covenants depending on the type of development. Similar to conventional stormwater management facilities, a maintenance agreement between the landowner and the County must be executed and recorded in the County land records prior to approval of the Stormwater Management Design Plan. For IMPs located on individual residential building lots, an additional legal document(s) is usually necessary to fully define the HOA's and homeowner's maintenance responsibilities and obligations. For example, the homeowner may be responsible for maintenance of an IMP that captures runoff from the rooftop and driveway with HOA's role limited to oversight and enforcement of the maintenance plan. The particular arrangements between the HOA and lot owner could be defined in the homeowners' association covenants. For IMPs that are designed to capture runoff from the road (a common area) and other off-lot runoff, the HOA may be solely responsible for all maintenance and upkeep of the facility. This type of arrangement also needs to be clearly defined through legal documents. The developer's attorney will typically prepare HOA covenants. The County may request review of covenants to ensure that adequate arrangements are in place to ensure long-term performance and maintenance of IMPs.

Public outreach and education is a key component of LID and must be integrated into the entire development process. The developer is responsible for preparing and distributing public outreach materials to builders and construction managers, potential buyers and homeowners' associations explaining the responsibilities, benefits, function, and importance of community participation for the long-term performance of LID facilities.

The Design Manuals contain further information on LID public outreach programs.

Where LID designs incorporate IMPs on individual lots and homeowners will be primarily responsible for their maintenance, the maintenance plan must incorporate a means to ensure homeowners:

Are made aware of their responsibilities for maintaining the IMPs, including the requirement that modification of the IMP not be made without the permission of the County,

Are provided materials adequately explaining the purpose, design, inspection, and maintenance aspects of the IMP located on their lot,

Perform or provide for required inspection and maintenance of their IMPs.

See sample maintenance plans for IMPs in Sections 10.19, 10.20, and 10.21.

9.4 Maintenance Inspections

Responsibility for the operation and maintenance of the stormwater management facilities and storm drainage system shall remain with the property owner or an owner's association. All maintenance activities shall be in accordance with standard maintenance practices for stormwater management facilities and the stormwater management design manuals.

The landowner or a representative of the owner shall inspect stormwater management facilities within 24 hours after each rainfall event of one inch or more. The owner shall keep written records of these inspections and any necessary repairs, and furnish records to the County upon request.

Chapter
10

10 Appendices

10.1 Appendix 1 Stormwater Management Ordinance

This Appendix contains the text of the Culpeper County Stormwater Management Ordinance as approved by the Culpeper Board of Supervisors on June 3, 2008. It is subject to change. Please refer to the County's website at web.culpepercounty.gov for updated information.

Chapter 11A

STORMWATER MANAGEMENT

Article I. In General

Article IV. General Criteria

Division 1. General Performance Criteria

Division 2. Water Quality

Division 3. Water Quantity

Division 4. Design Storm Frequency

Division 5. Structures or Facilities

Division 6. Stream Buffers

Division 7. Low Impact Development

Article V. Construction Inspection

Sec. 11A-31. Inspections.
Sec. 11A-32. Post Construction final inspection and as-built plans.

Article VI. Post-construction Maintenance, Inspection, and Repair of Stormwater Facilities

Sec. 11A-33. Maintenance of stormwater facilities.
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Article VII. Enforcement and Penalties

Sec. 11A-35.General procedures.
Sec. 11A-36. Violations.
Sec. 11A-37. Stop work orders.
Sec. 11A-38. Civil and criminal penalties.
Sec. 11A-39.Restoration of lands.
Sec. 11A-40. Holds on certificates of occupancy.

ARTICLE 1. IN GENERAL

DIVISION 1. GENERAL PROVISIONS

Sec. 11A-1. Statutory Authority.

This chapter is adopted pursuant to the authority conferred by the Virginia Stormwater Management Act [Article 1.1 (§10.1-603.1 et seq.) of Chapter 6 of Title 10.1 of the Code of Virginia].

Sec. 11A-2. Purpose.

The purpose of this chapter is to establish minimum stormwater management requirements and controls to protect properties; safeguard the general health, safety, and welfare of the public residing in watersheds within Culpeper County; and to protect aquatic resources. This chapter seeks to meet the preceding purpose through the following objectives:

(a) Requirement that land development and land conversion activities maintain the after-development characteristics, as nearly as practicable, to the pre-development characteristics in order to reduce flooding, siltation, stream bank erosion, and property damage;

(b) Establishment of minimum design criteria for the protection of properties and aquatic resources, downstream from land development and land conversion activities, from damages due to increases in volume, velocity, frequency, duration, and peak flow rate of storm water runoff;

(c) Establishment of minimum design criteria for measures to minimize non-point source pollution from stormwater runoff which would otherwise degrade water quality;

(d) Promotion of low-impact development (LID) techniques complimented by the use of conventional stormwater management;

(e) Establishment of provisions for the long-term responsibility for and maintenance of stormwater management control devices and other techniques specified to manage the quality and quantity of runoff; and

(f) Establishment of certain administrative procedures for the submission, review, approval, and disapproval of stormwater plans, and the inspection of approved projects.

Sec. 11A-3. Applicability.

(a) Except as provided for in §11A-3(b) and Article II of this chapter, all land development projects shall comply with the requirements of this chapter. To prevent the adverse impacts of stormwater runoff, the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, has developed a set of performance standards that must be met on new development or redevelopment sites. These standards apply to any land development or land use conversion activity disturbing one acre or more of land.

(b) The following activities are exempt from these stormwater performance criteria:

(1) Clearing of lands specifically for agricultural purposes including the management, tilling, planting, or harvesting of agricultural, horticultural, or silvicultural crops;

(2) Single-family residences separately built and disturbing less than one acre including additions or modifications to existing single-family detached residential structures;

(3) Land development projects that disturb less than one acre of land area;

(4) Linear development projects, provided that: (i) less than one acre of land will be disturbed per outfall or watershed; (ii) there will be insignificant increases in peak flow rates, and (iii) there is no existing or anticipated flooding or erosion problems downstream of the discharge point.

(c) When a site development plan is submitted that qualifies as a redevelopment project as defined in §11A-7 of this chapter, decisions on permitting and on-site stormwater requirements shall be governed by the stormwater sizing criteria found in the current Virginia Stormwater Management Handbook and Culpeper County adopted LID manuals. This criterion is dependent on the amount of impervious area created by the redevelopment and its impact on water quality. Final authorization of all redevelopment projects will be determined after review by the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies.

Sec. 11A-4. Compatibility with other permit and ordinance requirements.

This chapter is not intended to interfere with, abrogate, or annul any other ordinance, rule or regulation, statute, or other provision of law. The requirements of this chapter should be considered minimum requirements, and where any provision of this chapter imposes restrictions different from those imposed by any other ordinance, rule or regulation, or other provision of law, whichever provisions are more restrictive or impose higher protective standards for human health or the environment shall be considered to take precedence.

Sec. 11A-5. Severability.

If provisions of any article, section, subsection, paragraph, subdivision or clause of this chapter shall be judged invalid by a court of competent jurisdiction, such order of judgment shall not affect or invalidate the remainder of any article, section, subsection, paragraph, subdivision or clause of this chapter.

Sec. 11A-6. Stormwater management handbook.

The Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, will utilize the policy, criteria, and information including specification and standards of the Virginia Stormwater Management Handbook, for the proper implementation of the requirements of this chapter. The Handbook is a list of acceptable stormwater treatment practices, including the specific design criteria for each stormwater practice. Design and construction in accordance with updates to the Handbook, regarding improvements in technology, engineering, science, monitoring, and local maintenance, will be presumed to meet the minimum water quality performance standards required by this chapter.

DIVISION 2. DEFINITIONS

Sec. 11A-7. Terms and words defined.

For the purposes of this chapter, certain terms and words used herein shall be interpreted as follows:

1.5 year storm: The frequency of a storm and the probability of such a storm occurring based on history. A one and half year storm means based on historic data the probability of the event occurring in any given year is 1 in 1.5 or roughly a 66% chance.

2 year storm: The frequency of a storm and the probability of occurrence based on historic data. A two year storm means the probability of the event occurring in any given year is 1 in 2 or a 50% chance.

10 year storm: The frequency of a storm and the probability of occurrence based on historic data. A ten year storm means the probability of the event occurring in any given year is 1 in 10 or a 10% chance.

100 yr storm: The frequency of a storm and the probability of occurrence based on historic data. A 100 year storm means that the probability of the event occurring in any given year is 1 in 100 or a 1 % chance.

24 hour storm: The duration of a storm. A twenty four hour storm is a storm that lasts for 24 hours.

Agreement in lieu of a plan: A contract between the plan-approving authority and the landowner.

Agricultural: The keeping of agricultural animals, livestock, grazing, and the tilling of the soil, the raising of crops, horticulture, forestry, and including the keeping and the processing of any products produced on the premises, such as milk, eggs, and the like; but excluding any industry or business such as fruit packing plants or similar uses where all products processed are not produced on said premise.

As-Built Checklist: A guideline for preparing as-built drawings.

Average land cover: A measure of the average amount of impervious surfaces within a watershed, assumed to be 16%.

Base flow: Flow in a channel due to soil moisture or ground water.

Best management practice (BMP): A structural or nonstructural practice which is designed to minimize the impacts of development on surface and groundwater systems.

Buffers: An area of land at or near a tributary streambank and/or wetland that has intrinsic water quality value due to the ecological and biological processes it performs or is otherwise sensitive to changes which may result in significant degradation to the quality of state waters.

Channel: A natural or artificial watercourse with a definite bed and banks that conducts continuously or periodically flowing water.

Deposition: sediment build up in a stream channel.

Detention basin: The temporary storage of stormwater runoff in a stormwater management structure with the goals of controlling peak discharge rates and providing gravity settling of pollutants.

Discharge: The peak flow of a particular pollutant measured in cubic feet per second.

Drainage easement: A legal right granted by a landowner to a grantee allowing the use of private land for stormwater management purposes.

Ephemeral stream: An ephemeral stream has flowing water only during, and for a short duration after, precipitation events in a typical year. Ephemeral stream beds are located above the water table year-round. Groundwater is not a source of water for the stream. Runoff from rainfall is the primary source of water for stream flow.

Erosion: Removal of soil particles by wind and/or water. Often the eroded debris (silt or sediment) becomes a pollutant via stormwater runoff. Erosion occurs naturally but can be intensified by human activities such as farming, development, road-building, and timber harvesting.

Extended detention basin: A stormwater management facility which temporarily impounds runoff and discharges it through a hydraulic outlet structure over a specified period of time to a downstream conveyance system for the purpose of water quality enhancement or stream channel erosion control. While a certain amount of outflow may also occur via infiltration through the surrounding soil, such amounts are negligible when compared to the outlet structure discharge rates and, therefore, are not considered in the facility's design. Since an extended detention basin impounds runoff only temporarily, it is normally dry during non-rainfall periods.

Facility: A device that controls stormwater runoff and changes the characteristics of that runoff including, but not limited to, the quantity and quality, the period of release, and the velocity of flow.

Flooding: A volume of water that is too great to be confined within the banks or walls of a stream, water body, or conveyance system and that overflows onto adjacent lands, causing or threatening damage.

Floodplain: Land which would be inundated by flood waters in a storm event of a one-hundred (100) year return interval.

Forested condition: Mature, healthy forest land condition.

Fractured bed rock: Exposed bed rock that is connected to aquifer marked by pocked topography and underground cavities.

Geotechnical investigation: On site soil conditions inspected and reported by a trained professional.

Grassed swale: An earthen conveyance system which is broad and shallow with erosion resistant grasses and check dams, engineered to remove pollutants from stormwater runoff by filtration through grass and infiltration into the soil.

Hotspot: An area where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater.

Hydrology: All bodies of water and their connectivity.

Infiltration: The process of percolating stormwater into the subsoil.

Integrated management practices: Low-impact development microscale and distributed-management techniques to maintain predevelopment site hydrology. Integrated management practices shall include bioretention facilities, dry wells, filter/buffer strips, grassed swales, rain barrels, cisterns, infiltration trenches, and amended soils as specified in low-impact development design manuals.

Intermittent stream: A natural stream or portion of a natural stream that has a defined bed and defined banks within which water flows in response to precipitation, through near surface groundwater flow, or from springs, and which is not a perennial stream.

Land cover: A vegetative condition of a parcel. Vegetative condition is associated with a specified curve number used to calculate runoff pollution.

Land development: The development or alteration of land which changes its purpose from pre-existing conditions.

Land disturbance activity: Any activity which changes the volume or peak flow discharge rate of rainfall from the land surface. This may include the grading, digging, cutting, scraping, or excavating of soil, placement of fill materials, paving construction, substantial removal of vegetation, or any activity which bares soil or rock or involves the diversion or piping of any natural or man-made watercourse.

Land use conversion: The official changing of the permitted land use to a new permitted land use; the result of a rezoning.

LID Natural Resource Assessment: Analysis or evaluation of on site natural features, prior to development, for use in development of stormwater management concept plans; to include a site visit, checklist, and a summary or narrative.

Linear development project: A land development that is linear in nature such as, but not limited to: (i) the construction of electric and telephone utility lines and natural gas pipelines; (ii) the construction of tracks, right-of-ways, private roads, bridges, communication facilities, and other related structures of a railroad company, (iii) highway construction projects, (iv) driveways.

Lot: A tract, plot, portion of a subdivision, or other parcel of land intended as a unit for the purpose, whether immediate or future, of transfer of ownership or for development.

Low-impact development (LID): An approach to site design and stormwater that seeks to maintain the site's predevelopment rates and volumes of runoff. LID accomplishes this through the minimization of impervious cover, strategic placement of buildings, pavement and landscaping, and the use of small-scale distributed management features collectively call "Integrated Management Practices" (IMPs).

Low-impact development manuals: Culpeper County adopted manuals, as incorporated by reference in this chapter.

National pollutant discharge elimination system (NPDES): A regulatory amendment made in 1987 to the Clean Water Act (1972) that requires a discharge permit for large city stormwater discharges, essentially treating them as point sources.

Non-tidal wetlands: Wetlands other than tidal wetlands that are inundated or saturated by surface or groundwater at a frequency and duration to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, as defined by the United States Environmental Protection Agency.

Parcel: see lot.

Parking lot: An area not within a building where licensed and operable motor vehicles may be stored for the purpose of temporary, daily or overnight off-street parking.

Peak discharge: The maximum volumetric flow rate passing a particular location during a storm event.

Peak flow: Maximum flow, at which time the water flow elevation is highest and flooding is the worst.

Percent impervious: The impervious area within the site divided by the area of the site multiplied by 100.

Perennial streams: Streams which typically run year round and are depicted as a continuous blue line on the most recent United States Geological Survey 7.5 minute topographic quadrangle map(scale 1:24,000), except for streams within a development area or area of infill and redevelopment that have been piped or converted legally and intentionally into stormwater conveyance channels such that the stream does not resemble or maintain the characteristics of a natural stream channel, as determined by the program authority.

Point of discharge: The geographic point of analysis to which runoff from a particular area of land is conveyed.

Pollutant load: The amount of pollutants running off the land. In Virginia pollutant load is based on the amount phosphorus, but can refer to other pollutants as well such as nitrogen.

Post-development: Conditions that reasonably may be expected or anticipated to exist after completion of the land development activity on a specific site or tract of land.

Pre-development: Conditions that exist at the time that plans for the land development of a tract of land are approved by the plan approving authority. Where phased development of plan approval occurs (preliminary grading, roads, utilities, etc.), the existing conditions at the time *prior to* the first time being approved or permitted shall establish pre-development conditions.

Recharge: The replenishment of underground water reserves.

Redevelopment project: A project that involves the process of developing land that is or has been previously developed.

Retention basin: A stormwater management facility that temporarily impounds runoff and discharges it through a hydraulic outlet structure to a downstream conveyance system, and also includes a permanent impoundment. Therefore, it is normally wet, even during non-rainfall periods.

Sediment deposition: The process of water creating a sediment deposit, through the laying down of granular material that has been eroded and transported from another geographical location.

Stream buffer: An area of land at or near a tributary stream bank and/or non-tidal wetland that has an intrinsic water quality value due to the ecological and biological processes it performs or is otherwise sensitive to changes which may result in significant degradation to the quality of state waters.

Site: The parcel of land being developed or designated planning area in which the land development project is located.

Stormwater drainage system: An engineered man-made or natural system that transports stormwater through an area, site, and/or drainage area.

Stormwater (management) impoundment structures: See facility.

Stormwater management design manuals: Virginia Stormwater Management Handbook and Culpeper County approved Low Impact Development Manual.

Stormwater management concept plan: A document containing preliminary material and narrative for describing how existing runoff characteristics will be affected by a land development project, and methods for complying with the requirements of this ordinance.

Stormwater management design plan: A document containing narrative information and computational analysis for describing how existing runoff characteristics will be affected by a land development project, and methods for complying with the requirements of this ordinance.

Stormwater runoff: Water originating from rainfall and other precipitation that ultimately flows into drainage facilities, rivers, streams, springs, seeps, ponds, lakes, and wetlands as well as shallow groundwater.

Stream impact: The effect of land use change on the local aquatic system.

Structure: See facility.

Surface water: Water other than groundwater, such as lakes, rivers, or streams.

Virginia Stormwater Management Act: Article 1.1 (§10.1-603.1 et seq.) of Chapter 6 of Title 10.1 of the Code of Virginia.

Virginia Stormwater Management Permit: A statement of the various methods employed by a locality to manage the runoff from land development projects and may include such items as local ordinances, policies and guidelines, technical materials, inspection, enforcement, and evaluation.

Virginia Stormwater Management Program (VSMP): The Virginia program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing requirements pursuant to the federal Clean Water Act, the Virginia Stormwater Management Act, the Virginia Stormwater Management Program (VSMP) Regulations, and associated guidance documents.

Virginia Stormwater Management Program (VSMP) Permit Regulations: Chapter 60 (4VAC50-60) of the Virginia Administrative Code.

Vegetative filter strip: A densely vegetated Article of land engineered to accept runoff as overland sheet flow from upstream development. It shall adopt any natural vegetated form, from grassy meadow to small forest. The vegetative cover facilitates pollutant removal through filtration, sediment deposition, infiltration and absorption, and is dedicated for that purpose.

Water quality volume: The volume equal to the first ½ inch of runoff multiplied by the impervious surface of the land development project.

Watershed: A defined land area drained by a river, stream, or drainage ways or system of connecting rivers, streams, or drainage ways such that all surface water within the area flows through a single outlet.

Wetlands: Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

Zoning Administrator: The Culpeper County Zoning Administrator or his designee, including, but not limited to, the County's certified Erosion and Sediment Control Program Administrator.

ARTICLE II. EXCEPTIONS

Sec. 11A-8. Generally.

Exceptions to the provisions of this chapter may be granted by the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, upon receipt of request for such exception in writing from the applicant or property owner. The request shall include descriptions, drawings, calculations, and other information that is necessary to evaluate the waiver of stormwater management requirements. An exception may be granted provided that:

(a) Exceptions to the criteria are the minimum necessary to afford relief;

(b) Economic hardship alone is not sufficient reason to grant an exception;

(c) Reasonable and appropriate conditions shall be imposed as necessary upon an exception granted so the intent of the chapter is preserved.

Sec. 11A-9. Low-impact development exceptions.

LID shall be considered prior to conventional stormwater management. An exception to implement LID may be granted provided that the stormwater management concept plan shall utilize, to the maximum extent practicable, low-impact development site planning in accordance with the low-impact development design manuals and calculation sheets. The maximum extent practicable may be determined in a *LID Natural Resource Assessment* meeting with the Culpeper County Planning Department, and/or the Culpeper Soil and Water Conservation District. The *LID Natural Resource Assessment* may be used to determine whether additional stream protection is appropriate.

Sec. 11A-10. Stormwater management requirement exceptions.

(a) The minimum requirements for stormwater management may be waived in whole or part provided at least one of the following conditions applies:

(1) It can be demonstrated that the proposed development is not likely to impair attainment of the objectives of this chapter;

(2) The County finds that meeting the minimum on-site requirements is not feasible due to the natural or existing physical characteristics of the site;

(3) The location of the land development project in the watershed is such that on-site stormwater management will result in increased peak flows on the main stream where the stream channel is not adequate to handle the increased peak flows. However, management of the water quality volume shall still be required. The applicant or property owner must provide supporting hydrologic analysis in accordance with the stormwater management design manuals;

(4) An off-site stormwater management facility provides the required controls;

(5) An existing regional stormwater management facility provides the required controls, and the property owner agrees to a pro-rata share contribution, if applicable.

(b) In instances where one of the conditions above, in §11A-10(a), applies, the applicant may apply for an exception to be relieved of strict compliance with the stormwater management provisions that are not achievable, provided that acceptable mitigation measures are taken. To be eligible for an exception, the applicant must demonstrate to the satisfaction of the County that the immediate downstream waterways will not be subject to:

(1) Deterioration of existing culverts, bridges, dams, and other structures;

(2) Deterioration of biological functions or habitat;

(3) Accelerated streambank or streambed erosion or siltation;

(4) Increased threat of flood damage to public health, life, and property.

Sec. 11A-11. Stream buffer requirement exceptions.

The following types of development shall not be required to retain, establish, or manage a stream buffer, provided that the requirements of Article IV General Criteria are satisfied:

(a) The construction, installation, operation and maintenance of electric, gas and telephone transmission lines, railroads, and activities of the Virginia Department of Transportation, and their appurtenant structures, which are accomplished in compliance with the Erosion and Sediment Control Law or an erosion and sediment control plan approved by the Virginia Soil and Water Conservation Board.

(b) The construction, installation, and maintenance by public agencies of water and sewer lines, including water and sewer lines constructed by private interests for dedication to public agencies, provided that:

(1) To the extent practical, the location of such water or sewer lines shall be outside of all stream buffer areas;

(2) No more land shall be disturbed than is necessary to construct, install and maintain the water or sewer lines; and

(3) All such construction, installation, and maintenance of such water or sewer lines shall comply with all applicable federal, state, and local requirements and permits, and be conducted in a manner that protects water quality.

ARTICLE III. STORMWATER MANAGEMENT PROGRAM PERMIT PROCEDURES AND REQUIREMENTS

No application for land disturbance will be approved unless it includes a stormwater management design plan as required by this chapter, detailing how runoff and associated water quality impacts resulting from the activity will be controlled or managed. A stormwater management plan shall consist of a concept plan, to ensure adequate planning for the management of runoff, and a design plan.

DIVISION 1. STORMWATER MANAGEMENT CONCEPT PLANS

Sec. 11A-12. Stormwater management concept plans.

(a) All preliminary plans of subdivision and minor and major site plans shall provide a stormwater management concept plan describing, in general, how stormwater runoff through and from the development will be conveyed and controlled.

(b) The stormwater management concept plan must be approved prior to submission of a stormwater management design plan (as part of the construction plans, final plan, or site plan) for the entire development, or portions thereof.

(c) A copy of the approved stormwater management concept plan shall be submitted with the stormwater management design plan. The Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, shall check the design plan for consistency with the concept plan and may require a revised stormwater management concept plan if substantial changes in the site development proposal have been made.

(d) The stormwater management concept plan shall utilize, to the maximum extent practicable, low-impact development (LID) site planning in accordance with the low-impact development design manuals. The maximum extent practicable shall be determined in a *LID Natural Resource Assessment* meeting with the Culpeper County Planning Department and/or the Culpeper Soil and Water Conservation District.

(e) At a minimum, the stormwater management concept plan will include the *LID Natural Resource Assessment* and a plan view of the site providing all appropriate information as identified in the stormwater management design manuals, or suitable information as adopted by the Board of Supervisors of Culpeper County.

(f) The stormwater management concept plan shall include a hydrologic/hydraulic analysis of the downstream watercourse for all concentrated surface waters that will be discharged from the project site. The Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, may request relocation of a stormwater outfall if other alternative discharge locations are practical.

(g) Where the land-disturbing activity results from the construction of a single family residence, inclusive of the driveway accessing the site, an agreement in lieu of a plan may be substituted for a stormwater management concept plan.

DIVISION 2. STORMWATER MANAGEMENT DESIGN PLANS

Sec. 11A-13. Stormwater management design plans.

(a) Except as provided for in Article II Exceptions, no grading or building permit shall be issued for land development without approval of a stormwater management design plan that demonstrates compliance with Article IV General Criteria.

(b) The applicant shall demonstrate that the project meets the criteria set forth in this chapter through submission of a stormwater management design plan. Failure of the applicant to demonstrate that the project meets these criteria, as determined by the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, shall be reason to deny approval of the plan.

(c) A stormwater management design plan containing all appropriate information as specified in §11A-14 shall be submitted to the Culpeper County Planning Department in conjunction with the construction plans, final plan, or site plan.

(d) Where the land-disturbing activity results from the construction of a single family residence, inclusive of the driveway accessing the site, an agreement in lieu of a plan may be substituted for a stormwater management design plan.

Sec. 11A-14. Stormwater management design plan contents.

The stormwater management design plan shall contain maps, charts, graphs, tables, photographs, narrative descriptions, explanations, and citations to supporting references as appropriate to communicate the information required by this chapter, the stormwater management design manuals, and the low-impact development design manuals. At a minimum, the stormwater management design plan shall contain the following:

(a) ***General.***

(1) Description of the project and proposed design, including how water quality, quantity and stormwater drainage requirements will be addressed.

(2) Proposed erosion and sediment controls, and proposed temporary and permanent stormwater management facilities.

(3) Project schedule, including a sequence of construction.

(4) Maps depicting all pertinent stormwater management information necessary for review of the plan as identified in the stormwater management design manuals, including, but not limited to maps of the drainage area, soils maps, and a plan view of the development project.

(5) Identification of offsite easements required.

(b) ***Stormwater management facilities.***

(1) Stormwater management facilities identified on a map, including details, plan, profile, cross sections, and other pertinent data necessary for review as identified in the stormwater management design manuals.

(2) Comprehensive hydrologic and hydraulic design calculations, including all assumptions and criteria, for the pre-development and post-development conditions for the design storms specified in this chapter or the stormwater management design manuals.

(3) If infiltration facilities are proposed, the location of existing and proposed wells and septic system drain fields shall be shown along with an analysis that supports the location of the infiltration facility in the soil type identified.

(4) A geotechnical report with recommendations and earthwork specifications in accordance with requirements in the stormwater management design manuals. The geotechnical engineer shall certify on a specifications sheet in the design plan that the geotechnical recommendations have been incorporated into the design of stormwater management facilities.

(5) A plan describing the woody and herbaceous vegetative stabilization and management techniques to be used within and adjacent to the stormwater management facility in accordance with standards in the stormwater management design manuals.

(6) Identification of all onsite and offsite, temporary and permanent easements needed for construction, inspection, and maintenance of stormwater management facilities in accordance with specifications in the stormwater management design manuals.

(7) A maintenance plan identifying the parts or components of the stormwater management facility that need to be maintained to ensure continued proper functioning of the facility. A maintenance agreement shall be executed between the responsible party and the Culpeper County Department of Planning.

(c) ***Low-impact development sites.***

(1) Integrated management practices identified on a map and corresponding design details in accordance with the low-impact development design manuals.

(2) Hydrologic computations to determine low-impact development stormwater requirements in accordance with the low-impact development design manuals.

(3) Hydrologic evaluation and design details for supplemental conventional stormwater management facilities in the event that integrated management practices alone cannot meet site stormwater management requirements.

(4) Identification of all storm drainage easements needed to establish locations of integrated management practices.

(5) Installation specifications for all integrated management practices.

(d) ***Stormwater drainage systems.***

(1) Hydrologic and hydraulic design calculations, including calculations for offsite drainage systems.

(2) Design specifications in accordance with the stormwater management design manuals.

(3) Identification of all easements needed for inspection and maintenance of drainage systems in accordance with specifications in the stormwater management design manuals.

(4) All existing and proposed drainage systems, natural or manmade, shall be analyzed according to the Virginia Erosion and Sediment Control Regulations Minimum Standard 19.

Sec. 11A-15. Stormwater management design plan approval.

(a) A maximum of thirty (30) calendar days from the receipt of an application will be allowed for preliminary review of the application to determine if the application is complete. During this period, the application will be accepted for review, which will begin the sixty-day review period, or it will be rejected for incompleteness. If rejected, the applicant will be informed in writing of the information necessary to complete the application.

(b) The sixty-day review period begins on the day the complete stormwater management design plan is accepted for review. During the sixty-day review period, the Zoning Administrator, or his designee, shall either approve or disapprove the plan and communicate the decision to the applicant in writing. Approval or denial shall be based on the plan's compliance with this chapter and the stormwater management design manuals. In cases where modifications are required to approve the plan, the County shall have an additional sixty (60) days to review the revised plan from the initial and any subsequent resubmission dates. If the plan is approved, one copy bearing certification of such approval shall be returned to the applicant. If the plan is rejected, the applicant shall be notified in writing of the reasons. A copy of the approved plan shall be kept on the project site.

(c) All plans, profiles, and specifications shall be distributed to the appropriate County departments and/or State agencies for review and recommendation.

(d) The applicant or any aggrieved party authorized by law may appeal the Zoning Administrator's decision of approval or disapproval of a stormwater management design plan application within thirty (30) days after rendering of such decision by the Zoning Administrator, to the Board of Supervisors.

Sec. 11A-16. Conditions of approval.

(a) The applicant shall comply with all applicable requirements of the approved plan.

(b) No substantive changes shall be made to an approved plan without review and written approval by the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies.

(c) The stormwater management design plan's approval expires in one year from the date of approval unless a final plat is recorded or unless work has actually begun on the site. The recordation of a final plat for a section of a subdivision (or initiation of construction in a section) does not vest the approval of the stormwater management design plan for the remainder of the subdivision. If the stormwater management design plan expires, the applicant shall file with the Culpeper County Planning Department for re-approval of the stormwater management design plan.

(d) Three (3) sets of certified as-built plans and one electronic copy on storage media acceptable to the County, meeting the specifications documented in the stormwater management design manuals, shall be submitted to the Zoning Administrator upon completion of the project. Each as-built plan shall have a certification statement by a professional licensed in Virginia to perform such work and provide photographic evidence that proper construction practices have been followed.

(e) The applicant shall be responsible for implementing the approved plan.

Sec. 11A-17. Fees.

Fees shall be paid to the County in accordance with the Culpeper County Fee Schedule to defray the cost of plan review, program administration, and necessary inspections.

ARTICLE IV. GENERAL CRITERIA

DIVISION 1. GENERAL PERFORMANCE CRITERIA

Sec. 11A-18. General performance criteria.

(a) Incorporation on the site of best management practices shall meet the water quality protection requirements set forth in §11A-19 and §11A-20 or §11A-21. For the purposes of this chapter, the "site" may include multiple projects or properties that are adjacent to one another or lie within the same drainage area where a single best management practice will be utilized by those projects to satisfy stormwater quality protection requirements;

(b) Any maintenance, alteration, use, or improvement to an existing structure that does not degrade the quality of surface water discharge, as determined by the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, may be exempted from the requirements of this article.

(c) The Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, may authorize the developer to use retention and detention basins or alternative best management practice facilities to achieve the performance criteria set forth in this article.

(d) The Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, may require evidence of all wetland and stream impact permits required by law prior to authorizing grading or other on-site activities.

DIVISION 2. WATER QUALITY

Sec. 11A-19. General water quality criteria.

Unless judged to be exempt according to the conditions found in Article II, the following criteria shall be addressed for stormwater management at all sites:

(a) All stormwater runoff generated from land development and land use conversion activities shall not discharge untreated stormwater runoff directly into a jurisdictional wetland or local water body without adequate treatment. Where such discharges are proposed, the impact of the proposal on wetland functions shall be addressed using a method acceptable to the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies. In no case shall the impact on functions be any less than allowed by the United States Army Corp of Engineers or the Virginia Department of Environmental Quality.

(b) Annual groundwater recharge rates shall be maintained by promoting infiltration through the use of structural and non-structural methods. At a minimum, annual recharge from the post development site shall mimic the annual recharge from pre-development site conditions.

(c) Land development projects shall comply with the water quality performance-based or technology-based criteria in accordance with §11A-20 and §11A-21.

(d) Stormwater discharges to critical areas with sensitive resources may be subject to additional criteria, or may need to utilize or restrict certain stormwater management practices at the discretion of Culpeper County. Prior to design, applicants are required to consult with the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, to determine if they are subject to additional stormwater design requirements. Groundwater protection areas around public water supplies, if established, shall be subject to additional criteria.

(e) Stormwater discharges from land uses or activities with higher potential pollutant loadings, known as “hotspots”, may require the use of specific structural BMPs and pollution prevention practices.

Sec. 11A-20. Performance-based water quality criteria.

For land development, the calculated post-development non-point source pollutant runoff load shall be compared to the calculated pre-development load based upon the average land cover condition or the existing site condition. A BMP will be located, designed, and maintained to achieve the target pollutant removal efficiencies specified in Table 1 to effectively reduce the pollutant load to the required level based upon the following four applicable land development situations for which the performance criteria apply:

(a) Situation 1 consists of land development where the existing percent impervious cover is less than or equal to the average land cover condition and the proposed improvements will create a total percent impervious cover which is less than the average land cover condition.
Requirement: No reduction in the after development pollutant discharge is required.

(b) Situation 2 consists of land development where the existing percent impervious cover is less than or equal to the average land cover condition and the proposed improvements will create a total percent impervious cover which is greater than the average land cover condition.
Requirement: The pollutant discharge after development shall not exceed the existing pollutant discharge based on the average land cover condition.

(c) Situation 3 consists of land development where the existing percent impervious cover is greater than the average land cover condition.

Requirement: The pollutant discharge after development shall not exceed 1) the pollutant discharge based on existing conditions less 10% or 2) the pollutant discharge based on the average land cover condition, whichever is greater.

(d) Situation 4 consists of land development where the existing percent impervious cover is served by an existing stormwater management BMP that addresses water quality. *Requirement:* The pollutant discharge after development shall not exceed the existing pollutant discharge based on the existing percent impervious cover while served by the existing BMP. The existing BMP shall be shown to have been designed and constructed in accordance with proper design standards and specifications, and to be in proper functioning condition.

Sec. 11A-21. Technology-based water quality criteria.

For land development, the post-developed stormwater runoff from the impervious cover shall be treated by an appropriate BMP as required by the post-developed condition percent impervious cover as specified in Table 1. The selected BMP shall be located, designed, and maintained to perform at the target pollutant removal efficiency specified in Table 1. Design standards and specifications for the BMPs in Table 1 which meet the required target pollutant removal efficiency shall be consistent with those provided in the Virginia Stormwater Management Handbook.

Table 1.

Water Quality BMP*	Target Phosphorous Removal Efficiency	Percent Impervious Cover
Vegetated filter strip	10%	16-21%
Grassed swale	15%	16-21%
Constructed wetlands	20%	22-37%
Extended detention (2x WQ Vol)	35%	22-37%
Retention basin I (3 x WQ Vol)	40%	22-37%
Bioretention basin	50%	38-66%
Bioretention filter	50%	38-66%
Extended detention-Enhanced	50%	38-66%
Retention basin II (4 x WQ Vol)	50%	38-66%
Infiltration (1 x WQ Vol)	50%	38-66%
Sand filter	65%	67-100%
Infiltration (2 x WQ Vol)	65%	67-100%
Retention basin III (4 x WQ Vol with aquatic bench)	65%	67-100%

*Innovative or alternative BMPs not included in this table may be allowed at the discretion of the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies.

DIVISION 3. WATER QUANTITY

Sec. 11A-22. Technical water quantity criteria.

In order to protect Culpeper County waters from the potential harms of unmanaged quantities of stormwater runoff (sediment deposition, erosion, and damage due to changes in runoff rate of flow and hydrologic characteristics, including but not limited to, changes in volume, velocity, frequency, duration, and peak flow rate of stormwater runoff), the following technical criteria and standards for stormwater management apply to land disturbing activities:

(a) Maintain post-development runoff rate of flow and runoff characteristics that replicate as nearly as practicable, the existing predevelopment runoff characteristics and site hydrology,

(b) Properties and receiving waterways downstream of any land development project shall be protected from erosion and damage due to increases in volume, velocity and frequency of peak flow rate of stormwater runoff in accordance with the Virginia Erosion and Sediment Control Law and/or Culpeper County Code Chapter 8 Erosion and Sediment Control.

(c) The Culpeper County Planning Department, in consultation with the Soil and Water Conservation District and/or other agencies, may determine that some watersheds or receiving stream systems require enhanced criteria in order to address the increased frequency of bankfull flow conditions brought on by land development projects. Therefore, in lieu of the reduction of the 2-year post-developed peak rate of runoff, the land development project being considered shall provide 24- hour extended detention of the runoff generated by the 1-year, 24- hour duration storm.

(d) The 10-year post-developed peak rate of runoff from the development site shall not exceed the 10-year pre-developed peak rate of runoff.

Sec. 11A-23. Water quantity criteria compliance.

Compliance with §11A-22 will be determined with use of the following:

(a) Physical surveys and calculations consistent with engineering practices acceptable to the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, to verify pre-development stream characteristics.

(b) Calculations for each point of discharge from the land disturbance to evaluate flooding and channel erosion impacts to receiving streams due to land-disturbing activities. Calculations will include any runoff from the balance of the watershed which also contributes to that point of discharge. Flooding and channel erosion impacts shall be evaluated taking the entire upstream watershed into account, including the modifications from the planned land disturbance. Good engineering practices and calculations shall be used to demonstrate post development stream characteristics, flooding, and channel erosion impacts.

(c) For purposes of computing predevelopment runoff, all pervious lands in the site shall be assumed prior to development to be in good condition (if the lands are pastures, lawns, or parks), with good cover (if the lands are woods), or with conservation treatment (if the lands are cultivated); regardless of conditions existing at the time of computation. Predevelopment runoff calculations utilizing other land cover values may be utilized provided that it is satisfactorily demonstrated that actual site conditions warrant such considerations.

Sec. 11A-24. Stream channel erosion.

Any land-disturbing activity that provides for stormwater management intended to address any flow rate capacity and velocity requirements for natural or manmade channels shall be deemed to satisfy the requirements for natural or manmade channels if the practices are designed to (i) detain the water quality volume and to release it over 48 hours; (ii) detain and release over a 24-hour period the expected rainfall resulting from the one year, 24-hour storm; and (iii) reduce the allowable peak flow rate resulting from the 1.5, 2, and 10-year, 24-hour storms to a level that is less than or equal to the peak flow rate from the site, assuming the site was in a good forested condition. “Good forested condition” is achieved through multiplication of the forested peak flow rate by a reduction factor that is equal to the runoff volume from the site when it was in a good forested condition divided by the runoff volume from the site in its proposed condition. In such instances, the land-disturbing activity shall be exempt from any flow rate capacity and velocity requirements for natural or manmade channels as defined in any regulations promulgated pursuant to § 10.1-562 or 10.1-570 of Virginia Erosion and Sediment Control Law, Title 10.1, Chapter 5, Article 4 (July 2006).

DIVISION 4. DESIGN STORM FREQUENCY

Sec. 11A-25. Design storm frequency.

The specified design storms shall be defined as 2- and 10-year 24-hour duration storms using the site specific rainfall distribution recommended by the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS). Use of Modified Rational Method is also permissible per the guidance provided in the Virginia Stormwater Management Handbook.

DIVISION 5. STRUCTURES OR FACILITIES

Sec. 11A-26. Stormwater management impoundment structures or facilities.

(a) Construction of stormwater management impoundment structures or facilities within wetlands and perennial streams will be avoided to the maximum extent practicable.

(b) Construction of stormwater management impoundment structures or facilities within a Federal Emergency Management Agency (FEMA) designated 100-year floodplain will be avoided to the maximum extent practicable. When this is demonstrated to be unavoidable, all stormwater management facility construction will be in compliance with all applicable requirements under the National Flood Insurance Program, 44 CFR Part 59 and local floodplain ordinances.

(c) Stormwater management impoundment structures that are not covered by the Impounding Structure Regulations (4VAC50-20) will be engineered for structural integrity for the 100-year storm event. In no case will the design standard be less than the 100-year storm event for any stormwater management impoundment structure.

(d) No adverse environmental impacts shall occur to any identified fractured bedrock. Permanent stormwater management impoundment structures or facilities shall only be constructed in fractured bedrock after completion of a geotechnical investigation in accordance with guidelines outlined in the Virginia Stormwater Management Handbook. Discharge of stormwater into fractured bedrock shall not occur unless in accordance with the technical criteria setout in this Article, unless otherwise allowed by law.

Sec. 11A-27. Regional (watershed-wide) stormwater management facilities.

The Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies may encourage the development of regional stormwater management plans. Land owners intending to develop large tracts of land are encouraged to develop regional plans where practical. The objective of a regional stormwater management plan is to address the stormwater management concerns in a given watershed with greater economy and efficiency by installing regional stormwater management facilities versus individual, site-specific facilities. The result will be fewer stormwater management facilities to design, build and maintain in the affected watershed.

DIVISION 6. STREAM BUFFERS

Sec. 11A-28. General stream buffer criteria.

For all development subject to this chapter, stream buffers shall be retained if present and established where they do not exist on any lands containing streams, and/or wetlands contiguous to these streams.

(a) The stream buffer shall be no less than one hundred (100) feet on each side of the Rappahannock, Rapidan, Hazel, and Thornton Rivers, no less than fifty (50) feet wide on each side of perennial streams, no less than twenty-five (25) feet on each side of ephemeral streams, intermittent streams, or streams with evidence of channel formation.

(b) Buffers shall be measured horizontally from the top of the stream bank if no wetlands exist and from the edge of contiguous wetlands.

(c) Each stream buffer shall be maintained and incorporated into the design of the land development to the fullest extent possible.

(d) Except for the activities pertaining to the management of a stream buffer identified in Article III Exceptions and the additional types of development which may be allowed in a stream buffer identified in §11A-27, no indigenous vegetation within the stream buffer shall be disturbed or removed, regardless of the size of the area affected.

Sec. 11A-29. Stream buffer development exceptions.

If otherwise authorized by the applicable regulations of zoning ordinances, the following types of development shall be allowed in a stream buffer, provided that the requirements of §11A-26 are satisfied:

(a) A building or structure which existed on the date of adoption of this chapter may continue at such location. However, nothing in this chapter authorizes the replacement, expansion or enlargement of such building or structure except as provided.

(b) On-site or regional stormwater management facilities and temporary erosion and sediment control measures such as a silt fences or super silt fence, provided that:

(1) Selected erosion and sediment measures do not harm the natural infiltration of the buffer and land disturbance is minimized.

(2) To the extent practical, as determined by the Zoning Administrator, the location of such facilities shall be outside of the stream buffer;

(3) No more land shall be disturbed than is necessary to provide for construction and maintenance of the facility, as determined by the Zoning Administrator;

(4) The facilities are designed and constructed so as to minimize impacts to the functional value of the stream buffer and to protect water quality; and

(5) Facilities located within a flood plain adhere to the flood plain regulations of Culpeper County and are designed and located, to the extent practical, to maintain their water quality and/or water quality control value, according the standards of this chapter, during flood conditions.

(c) Water-dependent facilities; water wells, passive recreation access, such as pedestrian trails and bicycle paths; historic preservation; archaeological activities; provided that all applicable federal, state and local permits are obtained.

(d) Development which will consist of a lake, pond, or ecological/wetland restoration project.

(e) Development which will consist of the construction and maintenance of a driveway or roadway, and the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, determines that the stream buffer would prohibit reasonable access to a portion of the lot which is necessary for the owner to have a reasonable use of the lot;

(f) Development on a lot which was of record prior to the date of adoption of this chapter, on which the development in the stream buffer will consist of the construction, installation and maintenance of water and sewer facilities or sewage disposal systems, and the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, determines that the stream buffer would prohibit the practicable development of such facilities or systems. Any such sewage disposal system must comply with all applicable state laws;

(g) Development on a lot which was of record prior to the date of adoption of this chapter, if the stream buffer would result in the loss of a building site, and there are no other available building sites outside the stream buffer on the lot, as determined by the Zoning Administrator.

(h) Road crossings and utility crossings; provided that crossings to the extent practicable are located at a site of minimum impact to buffers, preferably crossing at a 90 degree angle.

DIVISION 7. LOW-IMPACT DEVELOPMENT

Sec. 11A-30. Low-impact development criteria.

The use of low-impact development site planning and integrated management practices shall be evaluated as the first option to control stormwater runoff at the source and more closely approximate predevelopment runoff conditions. Low-impact development site design is intended to maximize conservation of open space, minimize impervious area, and manage the increase in runoff volume through filters and infiltration practices while complying with the requirements for stormwater management and peak flow rate attenuation set forth by the State and Culpeper County.

(a) Stormwater management design plans developed consistent with the requirements of this section shall satisfy the water quality and quantity performance criteria of §11A-19 through §11A-23.

(b) The methodology, design criteria, hydrologic analysis, and computational procedures for low-impact development stormwater management shall be those of the County approved LID manuals.

(c) Stormwater management design plans utilizing LID methodology shall not conflict with existing State or Culpeper County laws, ordinances, regulations or policies.

(d) Storm drainage easements shall be recorded to identify the locations of integrated management practices on lots or parcels. The property owner shall not remove or structurally alter integrated management practices without prior written approval from the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies.

(e) Stormwater management design plans shall be considered LID only if one or more of the following non-structural practices, and one or more of the following structural practices are both incorporated into the site design:

(1) Non-structural practices:

(i) Conservation of open space area in excess of zoning requirements

(ii) Reduction of impervious area through the use of clustering provisions (refer to Culpeper County Code, Appendix A: Zoning Ordinance, Section 9-5.)

(iii) Reduction of impervious area through alternative road design practices that are acceptable to VDOT and Emergency Management Services.

(iv) Buffer improvement and enlargement beyond requirements.

(v) Additional practices, as specified in County approved LID manuals.

(2) Structural practices:

(i) Stormwater runoff from parking lots may utilize stormwater management infiltration facilities and/or stormwater management filtering systems place within or near parking lot islands.

(ii) Integrated management practices to manage and reduce runoff volume on residential lots. Lots ½ acre or larger are permitted to have on-lot measures; for lots ½ acre or smaller, off-lot measures in common areas is encouraged.

(iii) Extended detention and conventional detention methods to meet State and Culpeper County standards of peak flow rate attenuation.

(iv) Utilization of flow dissipation and disconnection structures to reduce impact of concentrated flows.

(v) Additional practices, as specified in County approved LID manuals.

ARTICLE V. CONSTRUCTION INSPECTION

Stormwater management construction inspection shall utilize the final approved plans prepared in accordance with Article III: Stormwater Management Program Procedures and Requirements. In addition, the inspection shall comply with the latest version of the Erosion and Sediment Control Regulations, promulgated pursuant to Section 4 (10.1-566), Chapter 5 of Title 10.1 of the Code of Virginia.

Sec. 11A-31. Inspections.

Prior to the issuance of any permits, the Zoning Administrator shall require the owner to submit a reasonable performance bond with surety, cash escrow, letter of credit, or any combination thereof to ensure that action can be taken by the Zoning Administrator, at the applicant's expense, should the applicant fail, after proper notice and within the time specified, to initiate or maintain those measures identified in the approved stormwater management design plan. The performance bond or other surety shall be provided from a date prior to the issuance of any permit until after the requirements of the approved stormwater management/BMP plan have been completed including as-built plans as outlined in §11A-32, as determined by the Zoning Administrator. A final inspection, of all aspects outlined in the As-Built checklist, by the Culpeper County Planning Department or its designee is required before the release of any performance securities can occur.

(a) A preconstruction conference between the Culpeper County Planning Department and/or the Culpeper Soil and Water Conservation District, the applicant, and the person(s) performing the work shall be required.

(b) Periodic inspections of the stormwater management system construction shall be conducted by the staff of the Culpeper County Planning Department or their designated agent. If any violations are found, the property owner shall be notified in writing of the nature of the violation and the required corrective actions. No additional work shall proceed until any violations are corrected and all work previously completed has received approval by the Culpeper County Planning Department.

(c) If determined by the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, that there is a failure to comply with the plan, a written notice to comply shall be served upon the permittee or person responsible for carrying out the plan in accordance with Article VII Enforcement and Penalties of this chapter.

(d) Inspections during construction activity will be in accordance with Virginia Erosion and Sediment Control Regulation VAC50-30-60B or, if approved, with an alternative inspection program.

(e) Upon completion, the applicant is responsible for certifying that the completed project is in accordance with the approved plans and specifications (refer to the As-built checklist) and shall provide regular inspections sufficient to adequately document compliance. All inspections shall be documented and written reports prepared that contain the following information:

(1) The date and location of the inspection;

(2) Whether construction is in compliance with the approved stormwater management plan;

(3) Variations from the approved construction specifications; and

(4) Any violations that exist.

All such reports shall be submitted to the Culpeper County Planning Department.

Sec. 11A-32. Post-construction final inspection and as-built plans.

All applicants are required to submit as-built plans for any stormwater management practices located on-site after final construction is completed, in accordance with the As-Built Checklist. The plan must show the final design specifications for all stormwater management facilities and must be certified by a professional engineer.

ARTICLE VI. POST CONSTRUCTION MAINTAINENCE, INSPECTION, AND REPAIR OF STORMWATER FACILITIES

Sec. 11A-33. Maintenance of stormwater facilities.

(a) Responsibility for the operation and maintenance of the stormwater management facilities and storm drainage system shall remain with the property owner or an owner's association. All maintenance activities shall be in accordance with standard maintenance practices for stormwater management facilities and the stormwater management design manuals.

(b) If an approved stormwater management design plan requires structural or nonstructural measures, the owner shall execute a stormwater management facilities maintenance agreement and plan prior to the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, granting final approval for any development for which a permit is required. The agreement shall be recorded with the Clerk of the Circuit Court of Culpeper County prior to land disturbance activity.

(c) The stormwater management facilities maintenance agreement shall be in a form approved by the county attorney and shall at a minimum:

(1) Designate for the land development the owner, governmental agency, or other legally established entity which shall be permanently responsible for maintenance of the structural or non-structural measures required by the plan;

(2) Pass the responsibility for such maintenance to successors in title; and

(3) Ensure the continued performance of the maintenance obligations required by the plan and this article.

(4) Allow for right-of-entry by Culpeper County for inspection purposes, and for conveyance of easements to the County upon County request.

Sec. 11A-34. Inspections of stormwater facilities.

(a) To ensure proper performance of the stormwater facility, the property owner or owner's association is responsible for inspecting and performing all necessary maintenance and repairs to the stormwater management facility in accordance with the approved maintenance plan and the stormwater management design manuals as specified in the stormwater management facilities maintenance agreement. The responsible party shall keep written records of inspections and maintenance/repairs and make them available to the county upon request.

(b) The Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, shall be allowed, after giving notice to the owner, occupier, or operator of the land development, to conduct any inspection required by this chapter. The notice may be either verbal or in writing. Notice shall not be required if Culpeper County or its agents have entered into a right of entry agreement or if the owner has granted to the County an easement for purposes of inspection and maintenance.

ARTICLE VII. ENFORCEMENT AND PENALTIES

Sec. 11A-35. General procedures.

Upon determination by the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, that the owner has failed to comply with the approved stormwater management plan the following procedures shall apply:

(a) The Zoning Administrator shall serve upon the owner a written notice to comply. The notice shall be served by registered or certified mail and/or by delivery to the land development site. The notice shall specify the measures needed to comply with the plan and shall specify the time within such measures shall be completed.

(b) If the owner fails to take the corrective measures stated in the notice to comply within the time specified in the notice any grading, building or other permit for activities involving the land development may be revoked and the owner shall be deemed to be in violation of this chapter.

(c) If the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, determines, upon completion of a maintenance inspection, that maintenance or repair of the measures is neglected, or that any stormwater management facility is a danger to public health or safety, the County may perform the work necessary to assure that such measures or facilities are not a danger to public health or safety, and shall be entitled to recover the costs of such work from the owner.

Sec. 11A-36. Violations.

Any development activity that is commenced or is conducted contrary to this chapter or the approved plans and permit may be subject to the enforcement actions outlined in this article and the Virginia Stormwater Management Law.

Sec. 11A-37. Stop work orders.

Persons receiving a stop work order will be required to halt all construction activities. This stop work order will be in effect until the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, confirms that the development activity is in compliance and the violation has been satisfactorily addressed. Upon failure to comply within the time specified, the permit may be revoked and the penalties in §11A-36 enforced.

Sec. 11A-38. Civil and criminal penalties.

Any person who violates any provision of a local ordinance or program adopted pursuant to the authority of this chapter shall be guilty of a Class 1 misdemeanor and shall be subject to a fine not exceeding $1,000 or up to thirty days imprisonment for each violation or both. In addition, the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, may pursue the following actions:

(a) Apply to the circuit court to enjoin a violation or a threatened violation of the provisions of this chapter without the necessity of showing that an adequate remedy at law does exist.

(b) Without limiting the remedies which may be obtained in this article, may bring a civil action against any person for violation of this ordinance or any condition of a permit. The action may seek the imposition of a civil penalty of not more than $2,000 against the person for each violation.

(c) The Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, may provide and issue an order against any person who has violated or failed, neglected or refused to obey this chapter or any conditions of a permit, for the payment of civil charges for violations in specific sums, not to exceed the limit specified in §11A-38(b).

Sec. 11A-39. Restoration of lands.

Any violator may be required to restore land to its undisturbed condition or in accordance with a Notice of Violation, Stop Work Order, or Permit requirements. In the event that restoration is not undertaken within a reasonable time after notice, the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies, may take necessary corrective action, the cost of which shall be covered by the performance bond, and/or become a lien upon the property until paid.

Sec. 11A-40. Holds on certificates of occupancy.

Certificates of occupancy shall not be granted until corrections to all stormwater practices have been made in accordance with the approved plans, Notice of Violation, Stop Work Order, or Permit requirements, and accepted by the Culpeper County Planning Department, in consultation with the Culpeper Soil and Water Conservation District and/or other agencies.

10.2 Appendix 2 Natural Resource Assessment, LID Site Design Checklist, and LID Computations Worksheet

10.2.1 Natural Resource Assessment

Provide a Qualitative Narrative describing the existing conditions of selected natural resources. Include any quantification that may support this assessment.

Components of the Resource Assessment Narrative:

1. Stream Channels: describe the current conditions including size estimates of width and depth, current stability of channel banks and bed, entrenchment, bed materials, and bank vegetation cover conditions,
2. Wetlands: describe locations, size, type and relationship to other hydrologic features,
3. Current drainage features of the site interior (i.e. slopes, watershed size, etc.),
4. Ponds: describe existing condition of the embankment, riser, and outfall area,
5. Buffers: describe type and condition of vegetation along perennial and intermittent streams within required buffer width,
6. Significant Soils: provide soil survey and soil reports from http://websoilsurvey.nrcs.usda.gov. Include extent of each soil type, typical depth to bedrock, typical depth to water table, and any know limitations (slopes, infiltration rates, linear extensibility, etc.)

10.2.2 LID Site Design Checklist

Prior to developing any structural stormwater practices on a site, significant reductions in stormwater quantity and quality impacts can be made through enhancements to site design. Below is a checklist of site design and planning practices that can be used to minimize stormwater impacts. Please check the practices that you are applying to your development, and note the extent to which each selected practices was implemented.

10.2.2.1 Site Design Technique 1

Minimize direct stormwater impacts to streams and wetlands to the maximum extent practicable. This can be accomplished by siting stormwater facilities outside of streams and wetlands, maintaining natural drainages, and preserving riparian buffers.

Achieved	**Not Achieved**	**Practice**
		Stormwater facilities located outside of streams and wetlands
		Natural drainage routes maintained on site.
		Riparian buffers preserved
		Distributed "Integrated Management Practices" used in lieu of centralized ponds

Describe actions taken:

____

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10.2.2.2 Site Design Technique 2

Preserve the natural cover on as much of the site as possible, especially for areas located on hydrologic soil groups (HSG) A and B. Natural vegetation helps maintain and preserve predevelopment hydrology on a site, thereby reducing the reliance on large-scale stormwater ponds. Natural cover on highly permeable soils increases filtration and infiltration.

Achieved	Not Achieved	Practice
		Utilize clustered development designs that preserve a significant portion of the site in a natural state.
		Utilize "fingerprint" clearing…limit the clearing and grading of forests and native vegetation to the minimum area needed for the construction of the lots, the provision of necessary access, and fire protection.
		Avoid impacts to wetlands or vegetated riparian buffers
		A & B Soils preserved in natural cover .

Describe actions taken:

10.2.2.3 Site Design Technique 3

Minimize the overall impervious cover. Roadways, sidewalks, driveways and parking areas are the greatest sources of site imperviousness. Impervious areas alter runoff and recharge values and site hydrology. For LID sites, managing the imperviousness contributed by road and parking area pavement is an important component of the site planning and design process. There are several methods that can be used to achieve a reduction in the total runoff volume from impervious surfaces.

Achieved	Not Achieved	Practice
		Utilize the minimum required width for streets and roads.
		Utilize street layouts that reduce the number of homes per unit length
		Minimize cul-de-sac diameters, use doughnut cul-de-sacs, or use alternative turnarounds
		Minimize excess parking space construction, utilize pervious pavers in low-use parking areas
		Utilize structured or shared parking
		Reduce home setbacks and frontages
		Where permitted, minimize sidewalk construction by utilizing sidewalks on one side only, utilizing “skinny” sidewalks, or substituting sidewalks with pervious trails through common greenspace.
		Substitute pervious surfaces for impervious wherever possible
		Where permitted, avoid the use of curb and gutter. Utilize vegetated open swales, preferably “engineered swales” with a permeable soil base.
		Minimize compaction of the landscape. In areas where soils will become compacted due to construction equipment, specify that the soils will be “disked” prior to seeding, and amended with loam or sand to increase absorption capacity.

Describe actions taken:

____

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10.2.2.4 Site Design Technique 4

Locate infiltration practices on HSG A and B soils wherever possible. HSG A & B soils are valuable resources on a site for facilitating infiltration of the increased runoff volume. Every effort should be made to utilize areas with these soils for IMPs that promote infiltration.

☐ Achieved

☐ Not Achieved

Describe actions taken:

____

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____

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10.2.2.5 Site Design Technique 5

Locate impervious areas on less permeable soils (HSG C and D).

Placement of impervious areas on lower permeability soils minimizes the potential loss of infiltration/recharge capacity on the site.

☐ Achieved

☐ Not Achieved

Describe actions taken:

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____

10.2.2.6 Site Design Technique 6

"Disconnect" impervious areas. "Disconnecting" means having impervious cover drain to pervious cover, i.e. downspouts draining to the yard, not the driveway. This decreases both the runoff volume and Time of Concentration. Disconnected parking lots, for example, can provide sheet flow into bioretention areas or engineered infiltration swales.

☐ Achieved

☐ Not Achieved

Describe actions taken:

10.2.2.7 Site Design Technique 7

Increase the travel time of water off of the site (Time of Concentration). Replicating the pre-development Time of Concentration is a key aspect in maintaining pre-development flow regime, and minimizing downstream impacts.

Achieved	**Not Achieved**	**Practice**
		Flatten grades for stormwater conveyance to the minimum sufficient to allow positive drainage.
		Increase the travel time in vegetated swales by using more circuitous flow routes, rougher vegetation in swales, and check dams.
		Utilize "engineered" swales in lieu of pipes or hardened channels. These swales will have shallow grades and will have a sand or gravel substrate below the sod to promote infiltration.

Describe actions taken:

10.2.2.8 Site Design Technique 8

Utilize soil management/enhancement techniques to increase soil absorption.

Achieved	Not Achieved	Practice
		Delineate soils on site for the preservation of infiltration capacity. Mark these areas in the field and restrict heavy equipment access.
		Require compacted soils in areas receiving sheetflow runoff (such as yards, downslope of downspouts) will be "disked" and amended with loam or sand prior to seeding/sodding.

Describe actions taken:

10.2.2.9 Site Design Technique 10

Revegetate all cleared and graded areas. Revegetating graded areas, planting, or preserving existing vegetation can reduce hydrologic impacts by creating added surface roughness as well as providing for additional volume storage.

☐ Achieved

☐ Not Achieved

Describe actions taken:

10.2.2.10 Site Design Technique 12

Use "engineered swales" for conveyance in lieu of curb and gutter wherever possible. Engineered swales utilize a sand substrate to maximize infiltration. Maintaining the predevelopment time of concentration (Tc) minimizes the increase of the peak runoff rate after development by lengthening flow paths and reducing the length of the runoff conveyance systems.

☐ Achieved

☐ Not Achieved

Describe actions taken:

10.2.2.11 Site Design Technique 13

Utilize level spreading of flow into natural open space. Wherever buffers or other areas of open space are preserved, ensure that they are made hydrologically functional by making them receiving areas for sheet flow, not concentrated flow. Use level spreaders on lot or pavement edges to help spread water into the preserved areas. Ensure that flow volumes do not cause channelized flow and erosion in receiving buffers.

☐ Achieved

☐ Not Achieved

Describe actions taken:

10.2.3 LID Calculations Worksheet

10.2.3.1 Definitions

Low Impact Development (LID) – An approach to site design and stormwater management that seeks to maintain the site's pre-development rates and volumes of runoff. LID accomplishes this through the minimization of impervious cover, strategic placement of buildings, pavement and landscaping, and the use of small-scale distributed runoff management features that are collectively called "Integrated Management Practices" (IMPs).

Detention – The collection of runoff in a ponding area, depression, or storage chamber followed by its gradual release through an outlet into a receiving water body. Detention is one way to reduce a site's peak runoff rate to its pre-development peak rate for the storm event of a given magnitude, but is not an effective way to reduce the runoff volume.

Retention – The collection of runoff in a ponding area or receptacle where it is kept until it soaks into the ground through infiltration. Retention reduces the volume of runoff from a site and can also be effective in reducing the peak runoff rate if the retention volume is sufficiently large.

Time of Concentration (Tc) – The time for runoff to travel from the hydraulically most distant point in a catchment to the watershed outlet or study point.

10.2.3.2 Instructions

Before beginning the LID Calculations Worksheet, first evaluate your site design using the Natural Resource Assessment and Site Design Checklist. The use of the site design practices is a critical component in ensuring that the pre-development hydrology on a site can be maintained.

The following worksheet follows the process detailed in *LID Hydrologic Analysis* (see references). Designers should download a copy from the internet to assist in the completion of this worksheet.

Note: Development projects that are unable to create sufficient retention practices to maintain the predevelopment runoff volume should revisit the application of the site design practices to the site. The thorough use of site design practices will reduce post-development curve numbers, and can result in decreased stormwater detention and retention volume requirements.

Additionally, modifications to the design of bioretention practices, such as the inclusion of a gravel sump, can provide additional storage volume).

10.2.3.3 Computing Pre and Post-Development Composite Curve Numbers for LID Approach

$$CN_C = \frac{CN_1A_1 + CN_2A_2 \ldots + CN_jA_j}{A_1 + A_2 \ldots + A_j}$$

CN_C=Composite Curve Number
Aj=Area of each Land Cover
CNj=Curve Number for each Land Cover

a. LID Predevelopment Runoff Curve Number. The pre-development condition of the low-impact development site is required to be woods in good condition (LID Hydrological Analysis, pg. 37). Calculate pre-development composite curve number for the site, using woods in good condition.

HSG	**CN (woods good condition)**	**Area$_j$**	**% of Site**	**Area$_j$ X CN$_{j,pre}$**
A	30			
B	55			
C	70			
D	77			
	SUM			

$$CN_{C,pre} = \frac{\sum (CN_{j,pre} * A_j)}{\sum A_j}$$

b. For comparison purposes, calculate a composite curve number for the ***developed site***, using the **conventional TR-55 approach**.

Land Cover and Soil	**CN**	**Area**	**% of Site**	**Area X CN**
Connected – impervious	*98*			
Unconnected - impervious	*98*			
		SUM		

$CN_{C,post}$ = ________

c. Calculate a composite **custom LID curve number** for the site, following the approach in Section 4.3 (pages 22-24) of "LID Hydrologic Analysis*". *This is more detailed than the conventional TR-55 approach.* This approach factors in the use of higher permeability soils for infiltration and the use of "disconnectedness" (impervious cover flowing to pervious cover). Use an R factor of "1"

Use an R factor of "1" for bioretention facilities

$$CN_{LID} = CN_p + \left(\frac{P_{imp}}{100}\right) \times (98 - CN_p) \times (1 - 0.5R)$$

where:

R = ratio of unconnected impervious area to total impervious area;
CN_{LID} = LID curve number;
CN_p = composite pervious CN post development pervious surface only;
P_{imp} = percent of impervious site area.

Use an R factor of "1" for bioretention practices.

Calculate CN_p: Use the CN of the pervious surfaces only from table in "b." above

Calculate R

	Acerage
Unconnected Impervious Area	
Total Impervious Area	
R = Unconnected Impervious / Total Impervious Area	

$CN_{C,post}$ = ______ *(from above)*
CN_{LID} = _______

Reduction in CN achieved with site design = ______ *($CN_{C,post}$ - CN_{LID})*

d. Calculate the **pre-development** Time of Concentration (Tc) using TR-55 for each discrete drainage area discharging from the site. Utilize the site design practices described in “LID Design Strategies”*, such as flattening grades, lengthening flow paths, etc to reduce the Tc as much as possible. Then, calculate the **post-development** Time of Concentration (Tc_{LID}) for the same drainages.

	Drainage A	*Drainage B*	*Drainage C*	*Drainage D*	*Drainage E*	*Drainage F*
Tc_{pre}						
Tc_{LID}						

NOTE: For the LID approach to function effectively, the Tc_{LID} must be greater than or equal to Tc_{PRE}. If not, <u>STOP here</u> and incorporate practices to reduce it. See “LID Design Strategies” for details.

Step 1: Determine the Retention Volume Required to Maintain Pre-development Runoff Volume

a. Calculate the **Design Rainfall** for your site, per the procedure outlined on pages 36-38 of "LID Hydrologic Analysis*". This is the rainfall at which runoff would have initiated on the site, if it were vegetated with "woods in good condition".

$$P = 0.2 \times \left(\frac{1000}{CN_{C,pre}} - 10 \right)$$

Where P is the rainfall at which direct runoff begins.

P = _____

Calculated Design Rainfall = P x 1.5 (land cover variability factor)

Calculated Design Rainfall = ____

Compare your calculated value for Design Rainfall to the 1-year, 24 hour rainfall for Culpeper County, **USE the higher value for your design.**

Calculated Design Rainfall = ______ inches Assume 1-Year Storm = 3 inches	Enter Higher → → → → Value	Design Rainfall = ______inches

b. Use the charts starting on page 131-132 (3 inch and 4 inch charts for Storage Required to Maintain Pre-Development Runoff Volume) of this document to calculate inches of storage volume to **Maintain Predevelopment <u>Runoff Volume</u> using Retention Storage.**

Pre-Development $CN_{C,pre}$ = ___
Post-Development CN_{LID} = ___

Watershed Storage for the Design Rainfall = ___"

$$VR = \left(\frac{WatershedStorage}{12}\right) \times DA \times \left(\frac{43560}{Acres}\right) = \_\_\_\_ \ ft^3$$

VR = Volume of Pre Development Storage

Watershed Storage = Volume of Runoff Storage Required (inches)

DA = Drainage Area (Acres)

Step 2: Determine Storage Volume for Water Quality Protection

a. Per example 4.3, ensure that the Predevelopment Retention Storage Volume (Step 1.b) meets or exceeds the **"Water Quality Volume",** which is ½" of runoff from impervious areas on the site.

Preliminary Retention Storage Volume = ______ ft3 (From Step 1.b) Water Quality Volume = 0.5" * Imp. Area = _____ ft3	Enter Higher → → → → Value	Retention Storage Volume = ________ ft3

Following example 4.2 on page 29 of "LID Hydrologic Analysis*", **calculate the area of IMP's required** to be distributed evenly on the site to retain the Retention Storage Volume.

Step 3: Determine the Storage Volume for Maintaining Peak Runoff Rate Using 100% Retention

Using the Charts starting on page 141 of this document (3 inch and 4 inch Type II 24 hour storms), determine the **storage volume** required to **maintain peak Runoff Rate using 100% RETENTION storage.**

Pre-Development $CN_{C,pre}$ = ____
Post-Development CN_{LID} = ____

Watershed Storage for Design Rainfall = ____"

$$VR_{100} = \left(\frac{WatershedStorage}{12}\right) \times (DA \times 43560) = \_\_\_\_ \; ft^3$$

VR_{100} = Volume of 100% retention (cubic feet)

DA = Drainage Areas (Acres)

Watershed Storage = Volume of Runoff Storage (inches)

Step 4: Evaluate Need for Additional Detention Storage (Hybrid Design)

Compare the volumes required for volume control and peak rate control:

$\boldsymbol{VR_{100}}$ **=__________ ft³** **vs.** **VR=__________ ft³**

Volume for 100% Retention *Volume of Pre Development Storage*

If **VR >** $\boldsymbol{VR_{100}}$ then:

Design site IMPs to retain (infiltrate) the Retention Storage Volume.

No additional detention is required.

If $\mathbf{VR} < \boldsymbol{VR_{100}}$ then:

*(or if **Retention Storage Volume** is unachievable with infiltration IMPs due to site constraints) then a HYBRID DESIGN IS REQUIRED.*

Follow Steps 5,6, & 7 on pages 34-37, of "LID Hydrologic Analysis" to calculate additional detention or retention required to meet peak runoff rate. LID seeks to use distributed, micro-scale practices such as rain gardens, amended soils, green roofs, rain barrels, etc to retain this additional volume as well. If this is not practicable for the site, ponds can be used to detain the additional volume.

Step 5: Determine the Storage Volume for Maintaining Peak Runoff Rate using 100% Detention

Using the Charts found on pages 135 and 136 of this manual to determine storage volume required to **maintain peak runoff rate using 100% DETENTION storage.**

Pre-Development $CN_{C,pre}$ = ____
Post-Development CN_{LID} = ____

Watershed Storage Volume for Design Rainfall = _____"

$$V_{D100} = \left(\frac{WatershedStorage}{12}\right) \times \left(DA \times 43560\right) = \_\_\_\_ \ ft^3$$

V_{D100} = Volume of 100% Detention Storage (cubic feet)

Watershed Storage = Volume of Runoff Storage (inches)

DA = Applicable Drainage Area (acre)

Step 6: Hybrid Design

$$X = \frac{50}{V_{R100} - V_{D100}}\left[-V_{D100}\left(V^2{}_{D100} + 4\left(V_{R100} - V_{D100}\right)VR\right)^{0.5}\right]$$

X = Area ratio of retention storage to total storage

Additional Detention Storage Required =

$$VR \times \left(\frac{100}{X}\right) - VR = \_\_\_\_ \, ft^3$$

Retention Storage Required = VR = _____ft³

With a Hybrid Design, IMPs must be provided that can meet the Additional Detention Storage (calculated above) **<u>and</u>** Retention Storage (VR).

Step 7: Determine Hybrid storage amount of IMP site area with partial volume attenuation using hybrid design (required when retention area is limited)

$$\boldsymbol{X'} = \frac{50}{V_{R100} - V_{D100}}\left[-V_{D100} + \left(V^2{}_{D100} + 4\left(V_{R100} - V_{D100}\right)\boldsymbol{VR'}\right)^{0.5}\right]$$

X' = Ratio of available Retention storage to Total storage

VR' = Available Retention storage volume (cubic feet) (determined by the designer by analyzing the site constraints)

$$\boldsymbol{H'} = \boldsymbol{VR'} \times \left(\frac{100}{\boldsymbol{X'}}\right) = \_\_\_\_ \, ft^3$$

When there is limited suitability for Retention IMPs, VR' becomes the Retention Storage Volume (cubic feet) and H' is the required Detention Storage Volume (cubic feet).

Summary of Quantitative LID Results

Yes / No - Site design and impervious cover reduction practices were used to the maximum extent practicable to minimize runoff volume.

Yes / No - The design results in a post-development Tc equal to the pre-development Tc.

Yes / No - The entire **Retention Storage Volume** will be retained and infiltrated.

Yes / No / NA - If the entire **Retention Storage Volume** is not retained and infiltrated, the plans show that every practicable effort was made to implement runoff volume reduction efforts, and all potential green space areas were made hydrologically functional for retention.

Yes / No Detention practices were used to store any additional volume required to maintain the predevelopment peak rate.

References

1. ***Model Development Principles for the Central Rappahannock*** is available for download at http://for.communitypoint.org/pages/download.htm
2. **Low Impact Development National Manual. *Low-Impact Development Design Strategies An Integrated Design Approach.*** EPA 841-B-00-003. Available on the web at http://www.epa.gov/owow/nps/urban.html and via FTP at ftp://lowimpactdevelopment.org/pub/
3. **Low Impact Development National Hydrology Manual. *Low-Impact Development Hydrologic Analysis*.** EPA 841-B-00-002. Available on the web at http://www.epa.gov/owow/nps/urban.html and via FTP at ftp://lowimpactdevelopment.org/pub/
   NOTE: The appendices to the hydrology document include a series of charts which are required to calculate LID storage volumes. They are not currently available in the downloadable version, but selected charts from that series are attached to the end of this document.

Selected Charts for Calculating LID Storage Volumes

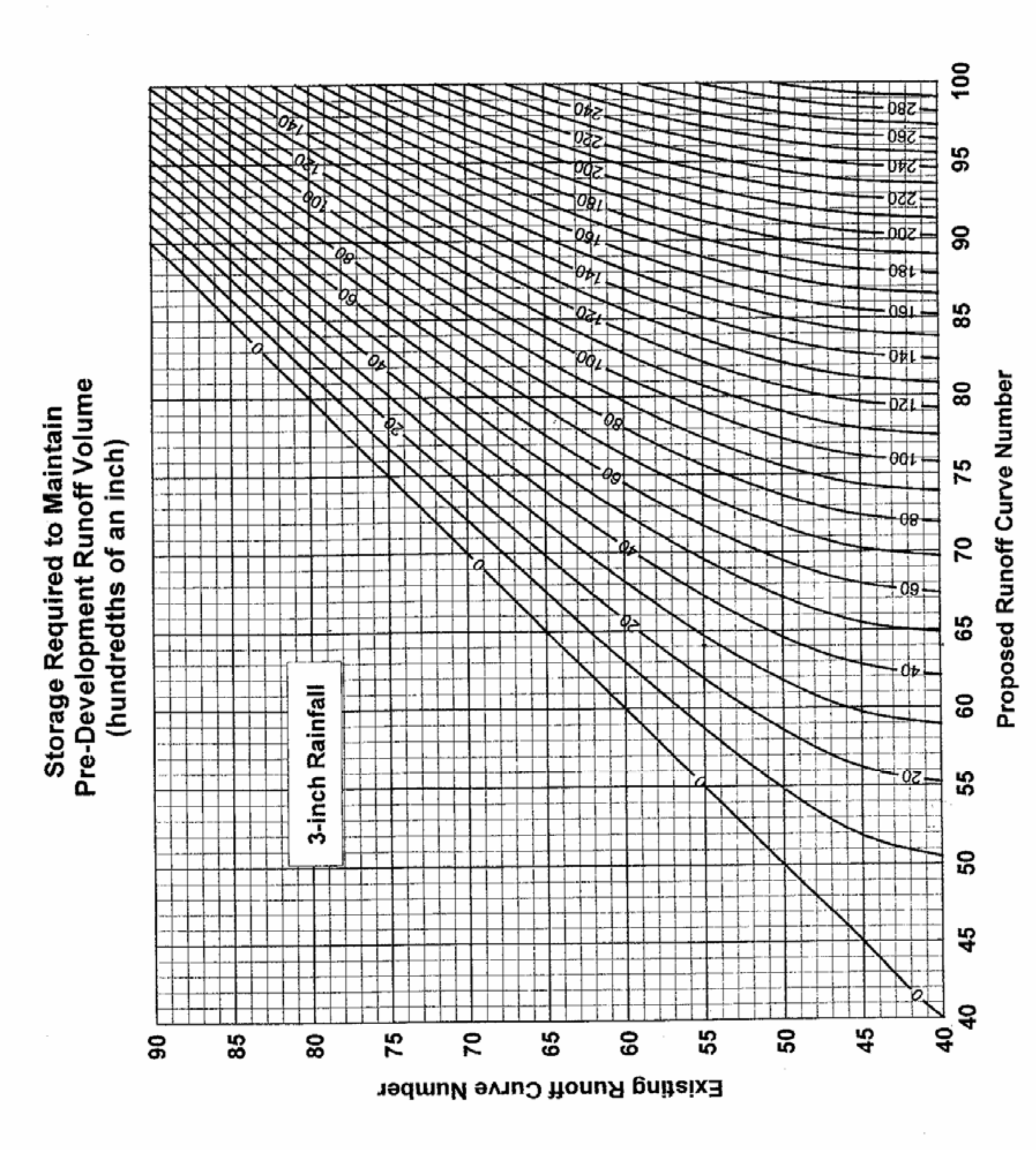
taken from

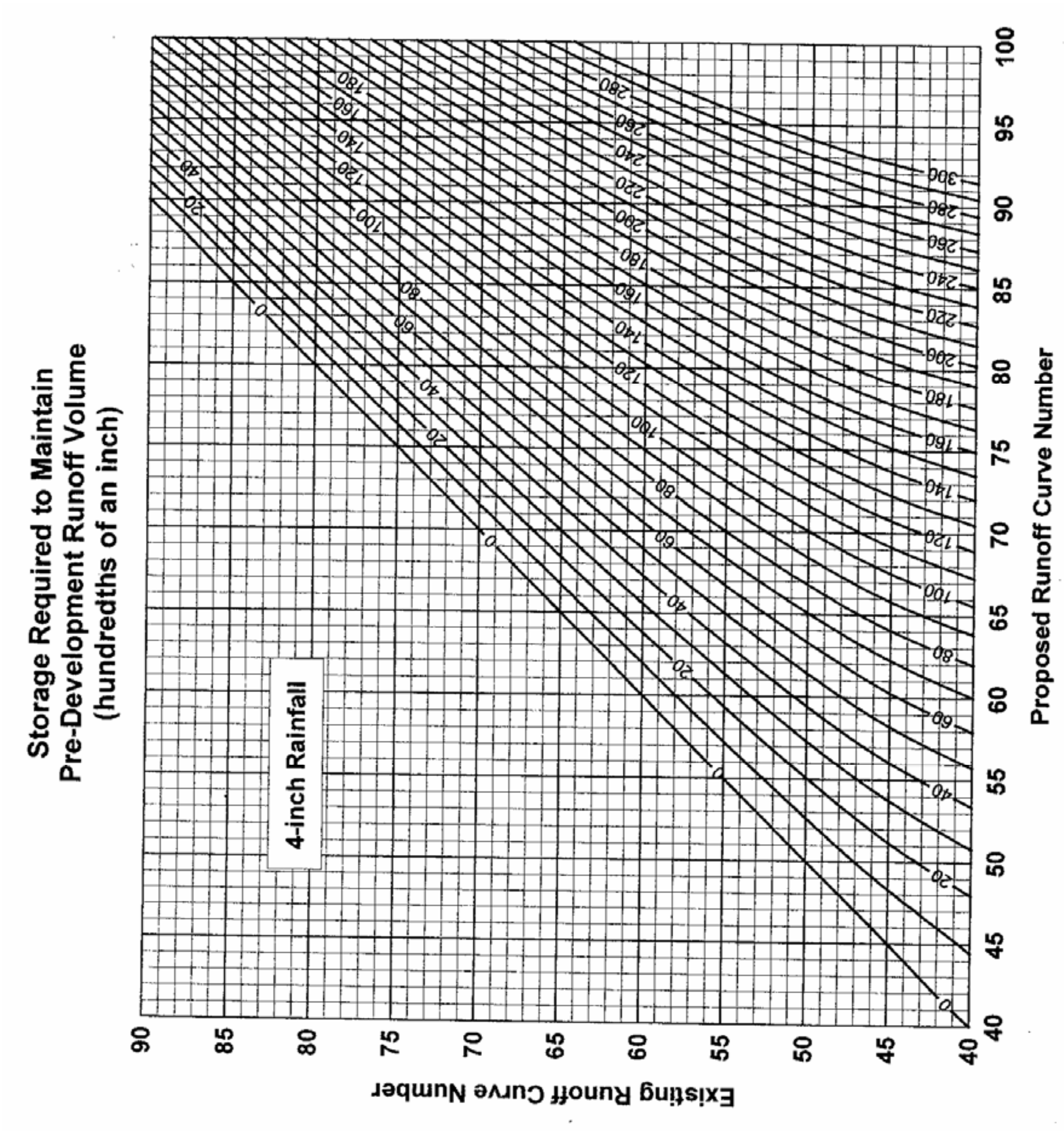
"LID Hydrologic Analysis"

(Low Impact Development National Hydrology Manual)

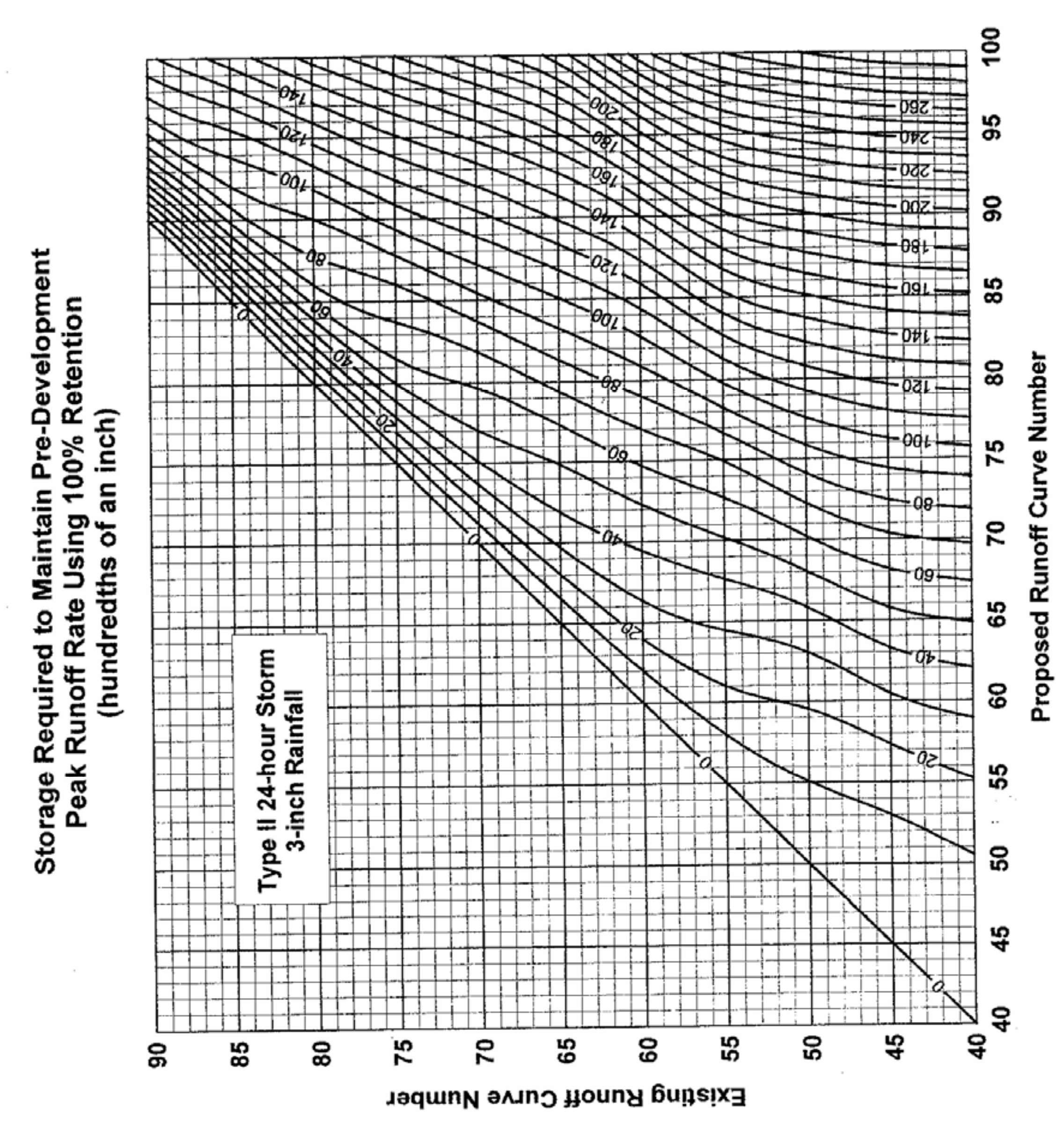
Prince Georges County, Md. – June 2002

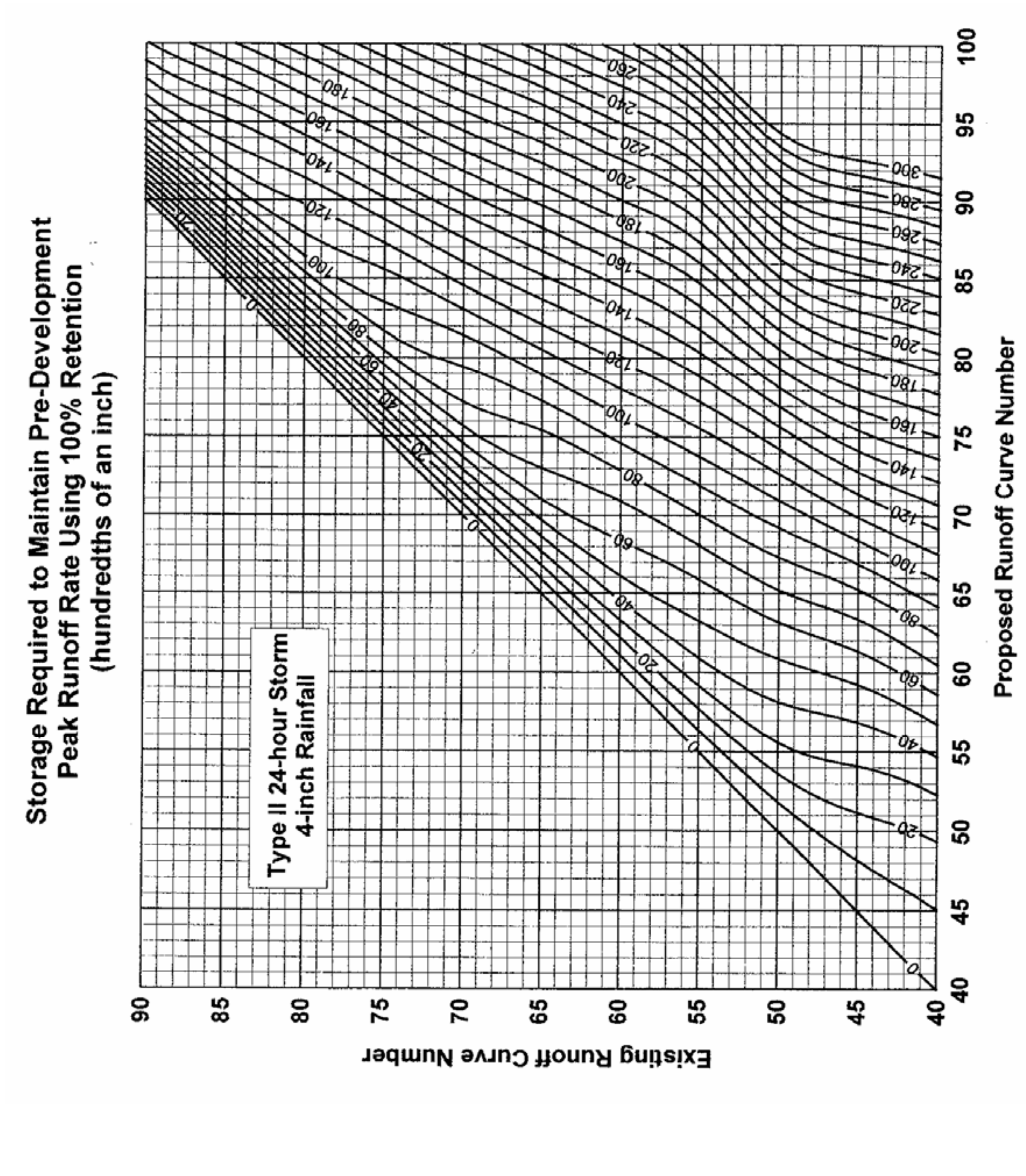
EPA 841-B-00-002

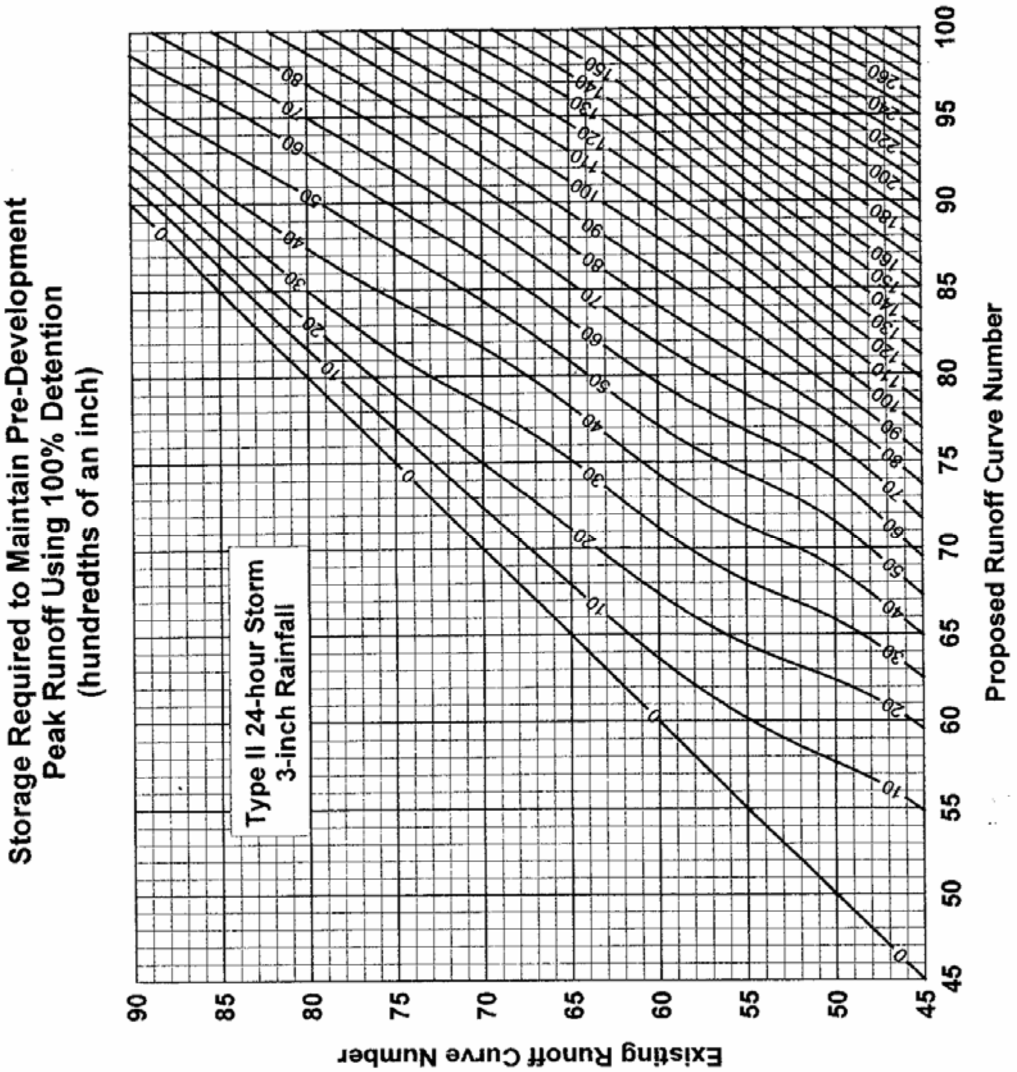

Storage Required to Maintain
Pre-Development Runoff Volume
(hundredths of an inch)
3-inch Rainfall
Proposed Runoff Curve Number
Existing Runoff Curve Number

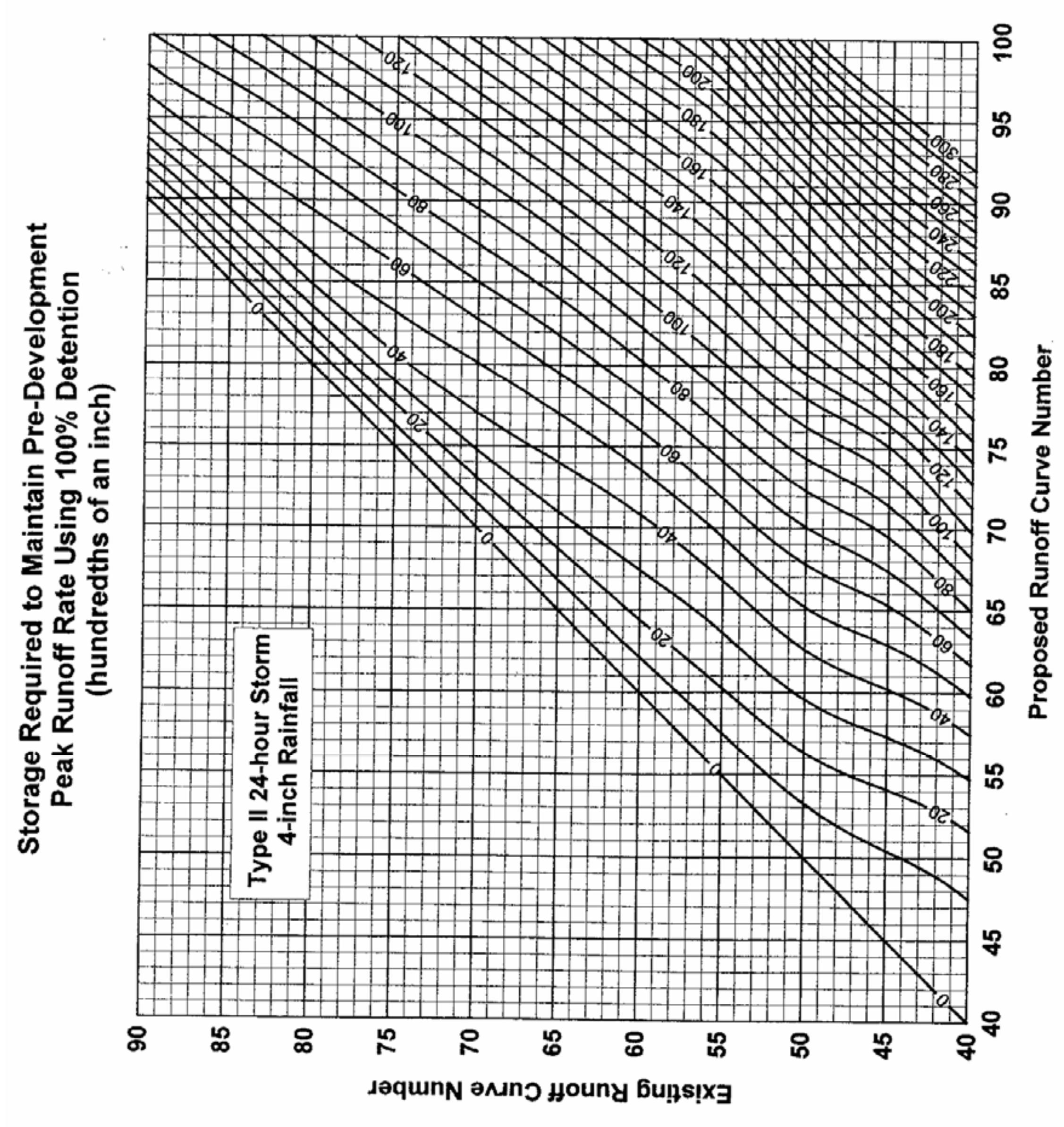


Storage Required to Maintain
Pre-Development Runoff Volume
(hundredths of an inch)
4-inch Rainfall
Existing Runoff Curve Number
Proposed Runoff Curve Number


Storage Required to Maintain Pre-Development
Peak Runoff Rate Using 100% Retention
(hundredths of an inch)
Type II 24-hour Storm
3-inch Rainfall
Existing Runoff Curve Number
Proposed Runoff Curve Number


Storage Required to Maintain Pre-Development
Peak Runoff Rate Using 100% Retention
(hundredths of an inch)
Type II 24-hour Storm
4-inch Rainfall
Proposed Runoff Curve Number
Existing Runoff Curve Number


Storage Required to Maintain Pre-Development
Peak Runoff Using 100% Detention
(hundredths of an inch)
Type II 24-hour Storm
3-inch Rainfall
Existing Runoff Curve Number
Proposed Runoff Curve Number


Storage Required to Maintain Pre-Development
Peak Runoff Rate Using 100% Detention
(hundredths of an inch)
Type II 24-hour Storm
4-inch Rainfall
Existing Runoff Curve Number
Proposed Runoff Curve Number
40
45
50
55
60
65
70
75
80
85
90
95
100

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10.3 Appendix 3 Determination of Channel Adequacy

Select control points of the channel. Good control points include points of entry of major tributaries, points of significant change of grade and/or cross-section, bridges or culverts, etc. The channel between each two control points is a reach.

Survey enough cross-sections at right angles to the centerline in each reach to determine the average cross-section. This should be done **in the field**, **not from a map**. The survey does not need to be referenced to a bench mark and it can be done with a hand level, survey rod and measuring tape. Channel grade can be determined from topographic maps unless the channel grade is less than 2%.

Note the relevant physical characteristics of the channel within each reach, including material comprising the channel bed and banks, vegetation, obstructions and other factors needed to determine a roughness coefficient (Manning's n). This information must also be **obtained in the field.** Factors used to determine n factors should be shown (pages V-135 – V-139 in the in the Virginia E&SC Handbook or HEC-2 Manual).

The following procedures may be used to determine channel adequacy. The procedure should be applied to each reach, beginning at the point where runoff from the site enters the defined channel and progressing down the stream to the final point of analyses

1. Determine the postdevelopment peak rate of runoff for each reach for the 2-year and 10-year storm. Calculate the runoff from the **entire** drainage area to the downstream end of each reach.
2. Calculate bankfull velocity and capacity. For a natural channel: 2-year velocity and depth. For a manmade channel: 2-year velocity and 10-year depth. If the bankfull capacity of a reach of the natural channel equals or exceeds the peak 2-year runoff rate, that reach of the channel is hydraulically adequate. If the channel in that reach cannot carry the 2-year peak rate of flow without overtopping of the banks, the channel is inadequate.
3. Determine the maximum permissible velocity **for the most erodible material in the channel cross-section**. If the bankfull velocity is less than the maximum permissible velocity, the channel is adequate with regard to erosion resistance. If the bankfull velocity exceeds the maximum permissible velocity, compute the depth and velocity for the 2-year peak rate of flow. If the 2-year velocity is less than the permissible velocity the channel is adequate with regard to erosion resistance. If the 2-year velocity exceeds the permissible velocity (see Va E&SC Handbook, Tables 5-14 and 5-22) the channel is inadequate.

The Culpeper County Stormwater Management Ordinance and Minimum Standard 19 of the Erosion and Sediment Control Ordinance require channel adequacy analyses of **any off-site, downstream receiving** channel that receives an increase in peak rate of flow due to development of a site. The downstream point of analyses is usually just upstream from a junction with another significant channel. In addition, sites discharging to an undefined channel must consider LID applications to disperse concentrated flow to sheet flow.

10.4 Appendix 4 Design of Dry Wells for Roof Water

Assessor's Parcel:_____________ Subdivision _________________________

Address:___________________________ Builder: _______________________

10.4.1 Soil Data

mapping symbol ___________ soil name _____________________________

permeability = ______ inches per hour, permeability used: ________per hour

depth to rock = _______ inches

depth to water table = ________ inches

10.4.2 Volume of Gravel Required

Assuming 40% void space in the gravel, one cubic foot of gravel will store 1/2 inch of runoff from 9.6 square feet or 1 inch of runoff from 4.8 square feet of roof.

A. Phosphorous removal efficiency of 50% or less

$$\frac{\text{Roof Area}\left(ft^2\right)}{9.6} = \_\_\_\_\_\_\_\_\_\_\_\_ ft^3$$

B. Phosphorous removal of 50% - 65%

$$\frac{\text{Roof Area}\left(ft^2\right)}{4.8} = \_\_\_\_\_\_\_\_\_\_\_\_ ft^3$$

10.4.3 Maximum Depth of Storage

Dry wells are designed to drain out completely in thirty hours and if you removed the gravel from 2.5 feet of water filled gravel there would be 1 foot of water (based on 40% void space).

$$\text{Maximum depth} = 30 \times 2.5 \times \_\_\_\_\_\_\_\_\_\_\_ \text{ inches per hour} = \_\_\_\_\_\_\_\_\_\_\_$$

10.4.4 Design Depth of Storage

Design depth of water may not exceed maximum depth of water. Bottom of dry well must be above water table (so it is filtered before it enters the water table) and bedrock. Bottoms of dry wells need to be level so trenches along the contour may be better than square holes on steep slopes. Equipment available and owner preferences should also be considered. Depth of storage refers to the stone =filled portion of the well; there would normally be about one foot of topsoil over the gravel. The top of the gravel should also be level so the depth of cover will vary where the adjacent land is sloping.

In a few cases, the depth to the bottom of the trench may be deeper in order to reach a more permeable soil.

Design depth of storage = ___________ inches or__________feet

10.4.5 Area of Storage

Allocate proportionately or use the procedure below for the area of roof which drains to each dry well.

$$\frac{\text{Volume of gravel}}{\text{Depth of storage}} = \underline{\hspace{3cm}}\ ft^2$$

10.5 Appendix 5 Filter Strips and Easements

Culpeper County accepts filter strips for areas with relatively low increases in imperviousness. See Minimum Standard 3.14 in the Virginia Stormwater Management Handbook. Length of filter strip on page 3.14-4 refers to the distance from the uphill edge to the downhill edge. Where steepness of slope (of the filter strip) is 2% or less, the minimum length is 25 feet. The length should increase by 4 feet for each one percent increase above 2%. The optimum filter strip length is 80 - 100 feet.

When used to meet water quality requirements these strips are permanent features. In order to ensure that they will be permanent, Culpeper County requires that these strips be placed in conservation easements or storm drainage easements. (See Section 3.9)

Where roads are constructed in large lot subdivisions, rigid lip level spreaders may also be used to treat runoff from the roads by converting channel flow to sheet flow and then allowing it to flow through filter strips.

SLOPE OF STRIP	MINIMUM LENGTH TOP TO BOTTOM	SLOPE OF STRIP	MINIMUM LENGTH TOP TO BOTTOM
IN %	FEET	IN %	FEET
1	25	16	81
2	25	17	85
3	29	18	89
4	33	19	93
5	37	20	97
6	41	21	101
7	45	22	105
8	49	23	109
9	53	24	113
10	57	25	117
11	61	26	121
12	65	27	125
13	69	28	129
14	73	29	133
15	77	30	137

10.6 Appendix 6 Anti-Vortex Devices and Trash Racks on Riser Type Spillways

There are two basic types of anti-vortex devices. The most common is referred to as a vertical plate device because it uses one or more vertical plates to reduce vortex flow. The other is referred to as a sleeve-type device since, basically, it is a pipe larger than the riser being used as a sleeve over the riser.

10.6.1 Vertical Plate Devices

The tops of the vertical plates must be no lower than design high water or the elevation at which orifice flow begins, whichever is lower. The vertical plates may consist of metal (steel, stainless steel), concrete or High Density Polyethylene (HDPE). The vertical plates must project out from the outside wall of the riser by at least 6 inches. The ends may be tapered (for aesthetic reasons) but the taper shall not be steeper than 39° (4 inches of rise in 5 inches of run). Minimum thickness of steel plates is ¼ inch. Minimum thickness of concrete plates is 6 inches; calculations should include appropriate reductions in weir length. Steel plates should be painted with a rust-resistent paint. These devices are smaller and lighter than sleeve-type devices and can be fabricated on-site.

10.6.2 Sleeve Type Devices

For permanent ponds, sleeve type devices usually consist of concrete. They tend to be large and heavy. They have low maintenance requirements, tend to last a long time and, according to some people, they are more aesthetically pleasing on concrete risers.

There are two basic designs. Both are essentially concrete caps that sit on the top of the riser. With all sleeve-type structures the area between the inside wall of the sleeve and the outside wall of the riser must equal or exceed the area of the inside of the riser.

Sleeves (or perhaps more accurately, caps) that sit on lintels have been available for quite some time. The two lintels must be placed towards the center of the riser in order to minimize reduction of weir length; calculations should include a weir length reduction of 4 times the width of the lintels. This device should not be used where the water elevation in the pond will exceed the top of the lintels.

Sleeves that sit on three 30° supports are relatively new. One of the disadvantages is that the weir length is reduced by 25%. One of the advantages is that the supports (and the slots) can be much higher than the lintels in the lintel type device. Use of neoprene pads to reduce damage to the concrete is required. The device and the top section of the riser are to be prefabricated.

10.6.2.1 Concrete Riser with Three 90° Slots and a Covered Sleeve

This antivortex device is essentially a length of concrete pipe with a cover over the top; this “sleeve” sits on the top of the riser. The top of the riser has three 90° slots (notches) and three 30° supports (segments of riser wall between the slots). The three slots have a combined weir length of ¾ of the circumference of the riser. When in place, the bottom of the sleeve should be at least 8” below the inverts of the three slots; this projection could be increased where subsurface draw-off is desired. The top of the sleeve should contain a removable grate or a vented manhole cover. Neoprene pads should be placed on the top of each support to minimize chipping and spalling. Where the slots are more than one foot high, rebar should be placed across the slots to prevent children from entering the riser through the slots.

RISER DIAMETER (Ft.)	RISER AREA (Sq.Ft.)	WEIR LENGTH (Ft.)	ORIFICE POINT HEAD (Ft.)
3.0	7.07	7.07	1.60
3.5	9.62	8.25	1.88
4.0	12.57	9.42	2.14
4.5	15.90	10.60	2.41
5.0	19.64	11.78	2.67
5.5	23.76	12.96	2.95
6.0	28.27	14.14	3.21
6.5	33.18	15.32	3.48
7.0	38.48	16.49	3.75
7.5	44.18	17.67	4.01
8.0	50.27	18.85	4.28
8.5	56.75	20.03	4.55
9.0	63.62	21.21	4.81
9.5	70.88	22.38	5.08
10.0	78.54	23.56	5.35
10.5	86.59	24.74	5.62
11.0	95.03	25.92	5.88
11.5	103.87	27.10	6.15
12.0	113.10	28.27	6.42

The area of opening between the inside wall of the sleeve and the outside wall of the riser must equal or exceed the area of the inside of riser.

Orifice point head is the depth of flow at which flow changes from weir flow to orifice flow if the supports are at least as high as the head. Riser type spillways are to be designed so that orifice flow does not occur at the top of the riser. At some point below this elevation, outflows through this spillway must be controlled by the barrel (outlet control). For determining this point, the weir flow coefficient was assumed to be 3.0 and the orifice flow coefficient was assumed to be 0.6.

10.7 Appendix 7 Antivortex Devices Covered Sleeve Over Three 90° Notches

OUTFLOW RATES

RISER	HEAD (feet)													
DIAMETER	0.25	0.50	0.75	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00
(feet)	OUTFLOW (cubic feet per second)													
3.0	2.65	7.50	13.77	21.21	38.96									
3.5	3.09	8.75	16.07	24.74	45.45									
4.0	3.53	10.00	18.36	28.27	51.94	79.97								
4.5	3.98	11.25	20.66	31.81	58.44	89.97								
5.0	4.42	12.50	22.96	35.34	64.93	99.97								
5.5	4.86	13.75	25.25	38.88	71.42	109.96								
6.0	5.30	14.99	27.55	42.41	77.92	119.96	167.65	220.38						
6.5	5.74	16.24	29.84	45.95	84.41	129.95	181.62	238.74						
7.0	6.19	17.49	32.14	49.48	90.90	139.95	195.59	257.11	323.99					
7.5	6.63	18.74	34.43	53.01	97.39	149.95	209.56	275.47	347.13					
8.0	7.07	19.99	36.73	56.55	103.89	159.94	223.53	293.84	370.28	452.39				
8.5	7.51	21.24	39.03	60.08	110.38	169.94	237.50	312.20	393.42	480.66	573.55			
9.0	7.95	22.49	41.32	63.62	116.87	179.94	251.47	330.57	416.56	508.94	607.29			
9.5	8.39	23.74	43.62	67.15	123.37	189.93	265.44	348.93	439.70	537.21	641.03	750.78		
10.0	8.84	24.99	45.91	70.69	129.86	199.93	279.41	367.30	462.84	565.49	674.76	790.29		
10.5	9.28	26.24	48.21	74.22	136.35	209.93	293.38	385.66	485.99	593.76	708.50	829.81	957.34	
11.0	9.72	27.49	50.50	77.75	142.84	219.92	307.35	404.02	509.13	622.04	742.24	869.32	1002.93	
11.5	10.16	28.74	52.80	81.29	149.34	229.92	321.32	422.39	532.27	650.31	775.98	908.84	1048.52	1194.70
12.0	10.60	29.99	55.09	84.82	155.83	239.92	335.29	440.75	555.41	678.59	809.72	948.35	1094.10	1246.64

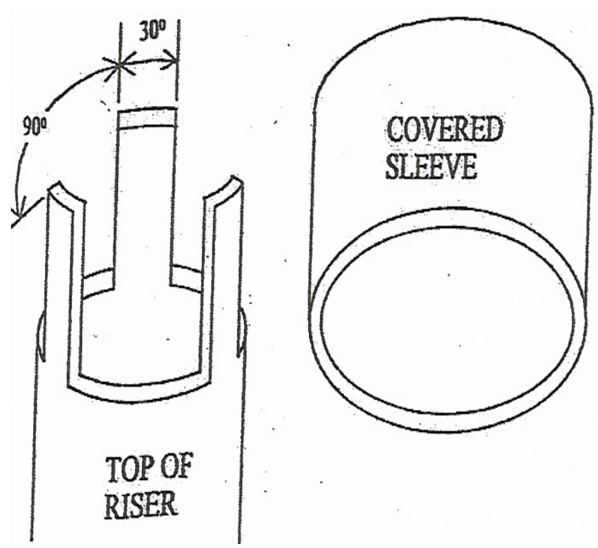
Weir flow coefficient used above = 3.0.

MINIMUM INSIDE DIAMETERS OF SLEEVES

	CLASS III RCP		MH - 1	
RISER	WALL	INSIDE DIA.	WALL	INSIDE DIA.
DIA.	THICKNESS	OF SLEEVE	THICKNESS*	OF SLEEVE
(feet)	(inches)	(inches)	(inches)	(inches)
3.0	4.00	57	6	60
3.5	5.25	68	6	69
4.0	5.75	77	6	77
4.5	6.25	86	6	86
5.0	6.75	95	6	94
5.5	7.25	104	6	102
6.0	7.75	114	6	111
6.5	8.25	123	6	119
7.0	8.75	132	6	128
7.5	8.50	140	6	136
8.0	9.00	149	6	145
8.5	8.50	157	6	153
9.0	10.00	168	6	161

Wall thickness may vary from plant to plant.

CONCEPT



SKETCH

10.8 Appendix 8 Crushed Rock Classifications

10.8.1 Riprap

				MINIMUM DEPTH		
	D_{15}	D_{50}	D_{100}	SEAS	VDOT	MANNING'S
VDOT NAME	(FEET)	(FEET)	(FEET)	(FEET)	(INCHES)	n
Class AI	0.7	0.9	1.35	2.7	22	0.039
Class I	0.8	1.1	1.65	3.3	26	0.040
Class II	1.3	1.6	2.4	4.8	38	0.043
Class III	1.9	2.2	3.3	6.6	53	0.045
Type I	2.6	2.8	3.6	7.2	34	0.047
Type II	4.0	4.5	6.1	12.2	60	0.051

10.8.2 Gravel

	D_{15}	D_{50}	D_{85}	DEPTH	MANNING'S
VDOT NAME	(INCHES)	(INCHES)	(INCHES)	(INCHES)	n
1	1.48	2.48	3.54	6	0.030
2	0.75	1.48	2.48	4	0.028
3	0.75	0.98	1.48	4	0.026
357	0.49	0.75	0.98	4	0.025
5	0.49	0.75	0.98	4	0.025
56	0.37	0.67	0.98	4	0.024
57	0.19	0.49	0.98	4	0.023
68	0.19	0.37	0.75	4	0.022
7	0.19	0.31	0.49	4	0.021
78	0.19	0.31	0.49	4	0.021
8	0.19	0.29	0.37	4	0.021
9	0.09	0.14	0.19	4	0.021
10	0.01	0.04	0.19	4	0.015

Individual quarries also have sizes other than those specified above. One size commonly available is “gabion” (diameters of 4 to 8 inches); this is usually rather uniform in size (not well-graded) and is commonly used in gabion baskets. Another size commonly available is “clean serge”; this is usually 2 to 4 inches in diameter and size tends to be rather uniform.

The common unit of measure for crushed stone is “Mean Spherical Diameter” (MSD).

This indicates the diameter of a given weight of stone if the stone was round. MSD is helpful to those who visually inspect riprap. Actually though, round stone is not desirable for use as riprap; the stone should be roughly rectangular. Round stone is more easily moved by water. Stone that is long and wide but thin (i.e. flagstone) is also more easily moved by water.

D (or d) followed by a subscript is a symbol used to show the gradation of stone. In this case, "D" is the symbol for mean spherical diameter. The subscript indicates the percent of stone (by weight) which is smaller than the specified size of stone. For most applications, graded (having various sizes) riprap is preferred rather than uniform riprap.

Manning's n = 0.0395 times $D_{50}{}^{1/6}$ (from Training Notebook, Course C, Basic Stormwater Management in Virginia, 1985).

10.9 Appendix 9 Sample Dam Construction Notes to be Modified by Designer/Geotechnical Engineer

1) Stake out the entire area to be covered by the dam and related structures.
2) Remove all topsoil, organic matter and stones from the area. Install a coffer dam or some other appropriate structure to divert runoff away from the work area during construction.
3) Excavate the core trench under the entire length of the dam. Depth to be determined by a qualified soil specialist or geotechnical engineer during excavation. Minimum acceptable bottom width is 4 feet. Minimum depth is 3 feet. The core trench should extend at least one foot into the underlying impermeable material unless that material is relatively unfractured bedrock. Side slopes should be no steeper than 1H:1V.
4) Fill in the core trench. All fill shall be placed under the supervision of a geotechnical engineer. The engineer will maintain a record of types of material used and degree of compaction achieved.
5) Install the pond barrel and the riser. The upstream 2/3 of the pond barrel will be bedded in concrete; the concrete must be plasticized or vibrated to ensure that there will be no voids. Flowable fill may be an option if so specified in the approved plans.. The downstream 1/3 of the barrel will be bedded in gravel wrapped in filter fabric. If the plan includes toe drains, they may be connected to the gravel bedding. The bedding should extend to at least the mid-point (haunch) of the barrel.

   The fill adjacent to the pipe and the fill over the pipe are to be compacted by manually-operated equipment (not pulled by or mounted on track-type or wheel-type equipment). Tampers mounted on backhoes are not acceptable. After the depth of fill over the pipe has reached a depth of at least 2 feet, large equipment, but not vibratory rollers, may be used. Vibratory rollers may be used after the depth of fill over the pipe exceeds 3 feet.
6) Place fill as directed by the geotechnical engineer.
7) Sideslopes shall be at least as flat as those shown on the approved plans. Flatter sideslopes will normally be acceptable.
8) A settling allowance of at least 5% is required. If degree of compaction is less than 95% but more than 90%, a settling allowance of 10% is required.
9) Emergency spillways consist of three sections. The control section is the high point. However, it is not a point. It is a broad, flat-bottomed weir. It should be level (all 4 corners should be at the same elevation). The distance from the upstream edge to the downstream edge should equal or

exceed the top width of the dam. The distance from one side to the other should be at least the distance specified in the approved plan. The entrance channel should have a continuous slope from the pool area of the pond to the control section. It should be at least as wide as the control section. Exit channels are usually riprapped. Please note that the specified dimensions are for the channel after the riprap is in place; the riprap shall be underlain by appropriate filter fabric. If the exit channel is designed to be narrower than the control section, the transition should be gradual. Control sections are not normally riprapped. All exit channels with velocities in excess of 5 feet per second will be riprapped. The top 6 inches of the control section may be topsoil.

10.10 Appendix 10 Sample Notes for Concrete Used In Construction of Dams to be Modified by Designer/Geotechnical Engineer

1) Unless otherwise specified in the approved site or construction plan, the following apply to all concrete. Minimum strength is 3,000 pounds. Minimum slump is 1" and maximum slump is 3". Cement shall be type I; if soil is found to be high in soluble sulfates, type V should be used after consulting with the design engineer (or the engineer who is to certify the structure). Exposed concrete will be water cured or covered with clear or white polyethylene film. All materials shall conform to appropriate ASTMs. Forms shall be clear of soil and other materials. Chamfer strips shall be placed in the corners of the forms and at the tops of wall placements to produce beveled edges on permanently exposed concrete surfaces. Edges of construction joints shall not be beveled except where indicated on the drawings. Consolidation of all concrete shall be by immersion-type vibrators operated in a nearly vertical position. Appropriate measures will be taken when temperatures are less than 50 degrees.
2) Unless it has been shown that the entrained air content of the concrete is at least 4%, by volume, as discharged at placement, an air entraining admixture shall be used in the concrete. The admixture shall conform to ASTM C 260; any air-entraining admixture used with type F or G chemical admixture shall be neutralized vinsol resin formulation. All admixtures will be used as specified in the designs or as approved by the design or certifying engineer. Any admixture, such as calcium chloride, or combination of admixtures which will introduce more than 0.1% chloride (to cement, by weight) shall not be used in concrete in which aluminum, galvanized metalwork or prestressing steel is to be embedded.
3) Note rebar schedule in drawings. Lubrication of forms is required unless otherwise specified.. Forms shall be removed within 24 hours after the concrete has hardened sufficiently to prevent damage by careful form removal and specified repair and curing will be commenced immediately thereafter.
4) All materials to be within the concrete shall be appropriate metal rebar, electrically welded wire fabric, mesh, ties, metal supports, etc. Interior wooden braces are not acceptable. Before reinforcement is embedded in the concrete, the surfaces of the bars, fabric and supports shall be cleaned of heavy flaky rust, loose mill scale, dirt, grease or other foreign substances which are objectionable. Heavy flake rust which can be removed by firm rubbing with burlap, or equivalent treatment, is considered objectionable. Plastic form spacers are acceptable. Where

applicable, fiber reinforcement is acceptable. Embedded ties for holding forms shall remain embedded and except where F1 finish is permitted, shall terminate not less than two diameters or twice the minimum dimension of the tie, whichever is greater, from the formed surfaces of the concrete. Recesses shall be filled with appropriate material.

5) All concrete shall be vibrated or superplasticized. It shall not be "watered down" to make it flow.

6) Where concrete is used to bed pipe larger than 12 inches in diameter, it shall be vibrated or superplasticized.

7) Pond risers shall be properly supported by metal or concrete blocks prior to pouring the base. An alternative would be to pour the base to the elevation of the bottom of the riser, set the bottom unit of the riser in place and then finish pouring the base.

8) Concrete surfaces likely to be walked upon, such as channel type spillways, shall have a rough surface to improve traction.

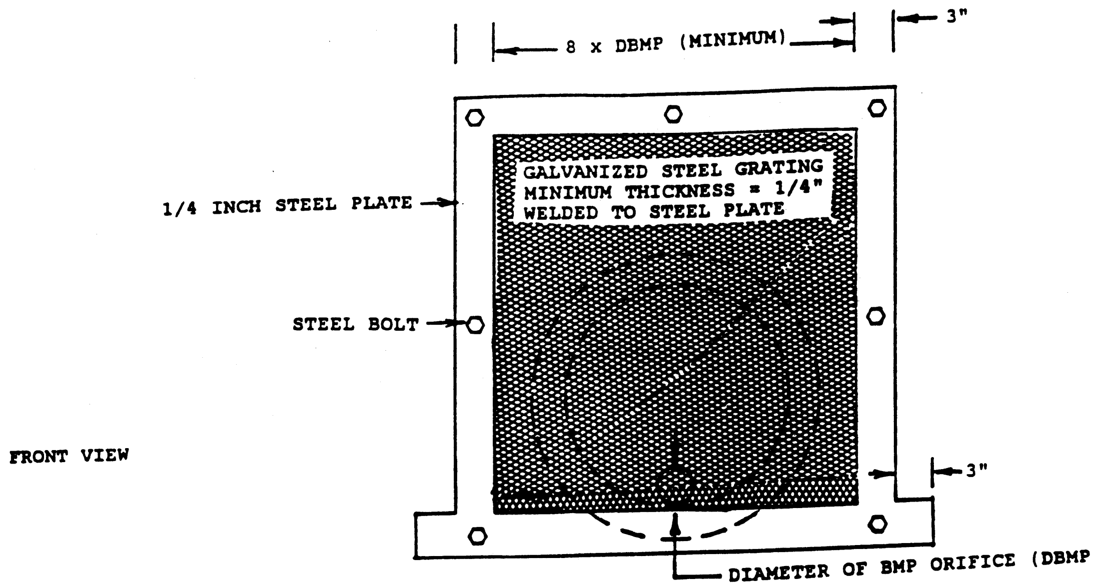
9) Concrete shall be deposited as nearly as practical in its final position and shall not be allowed to flow in such a manner that the lateral movement will cause segregation of the coarse aggregate from the concrete mass. Methods and equipment employed in depositing concrete in forms shall minimize clusters of coarse aggregate. Clusters that occur shall be scattered before the concrete is vibrated. Placing of additional concrete in forms shall not be delayed so long that the concrete placed before the delay is not readily penetrated by vibrators. It is especially important that adequate consolidation be achieved in the concrete at the interface of the fresh concrete and the underlying concrete. The vibrator shall repeatedly penetrate and thoroughly reconsolidate the upper portion of the underlying concrete which was placed before the delay.

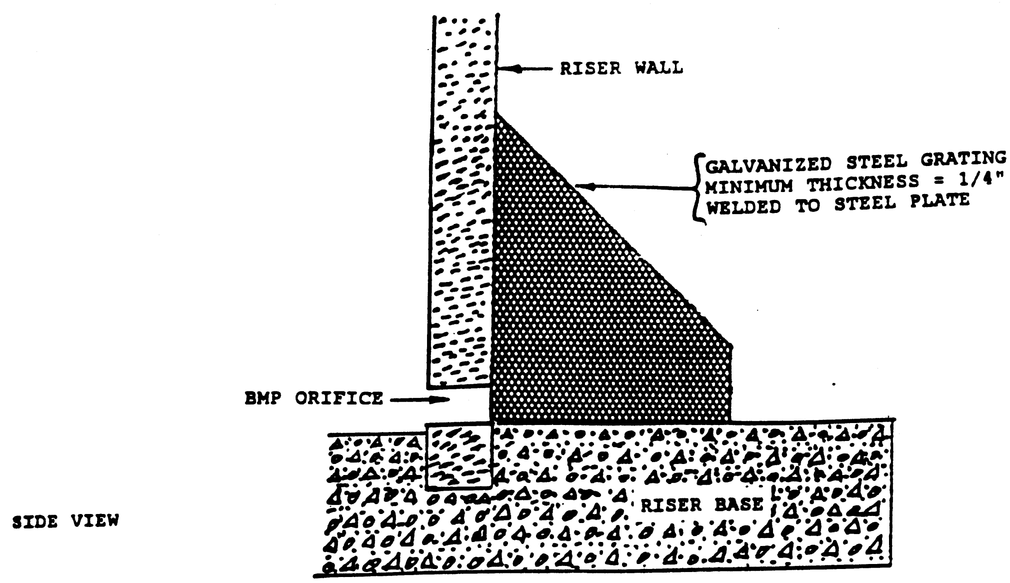
10) Where lift holes are permitted in concrete pipe, they shall be fully grouted and the surface of the grout on the inside of the pipe shall be uniform with the inside wall of the pipe. Pipe in which the smallest dimension (diameter in round pipe) is less than 36 inches shall not contain lift holes. Lift holes are not permitted in pond barrels. Where pipes enter risers, junction boxes, manholes, etc., the space between the outside wall of the pipe and the wall of the opening shall be filled with appropriate non-shrinking cement paste or cement mortar. Where the openings are large, concrete bricks may also be used. Other types (clay, cinderblock) of brick are not acceptable. All surfaces of the bricks must be covered with cement. The finished surfaces of the cement must be uniform with the inside and outside walls of the structure. The surfaces shall be smooth to minimize adverse effects of freezing and thawing and bricks shall not be visible. O-rings shall be properly lubricated and properly installed. All other types of joints shall be properly sealed. Concrete riser segments

shall be connected by bolting four galvanized or stainless steel plates (6” x 18” x 1/4” min.), uniformly spaced, to each pair of adjoining segments.

11) The bottoms of all risers, manholes, junction boxes, etc. shall be shaped in accordance with VDOT’s IS-1.

10.11 Appendix 11 Cage Type Trash Rack



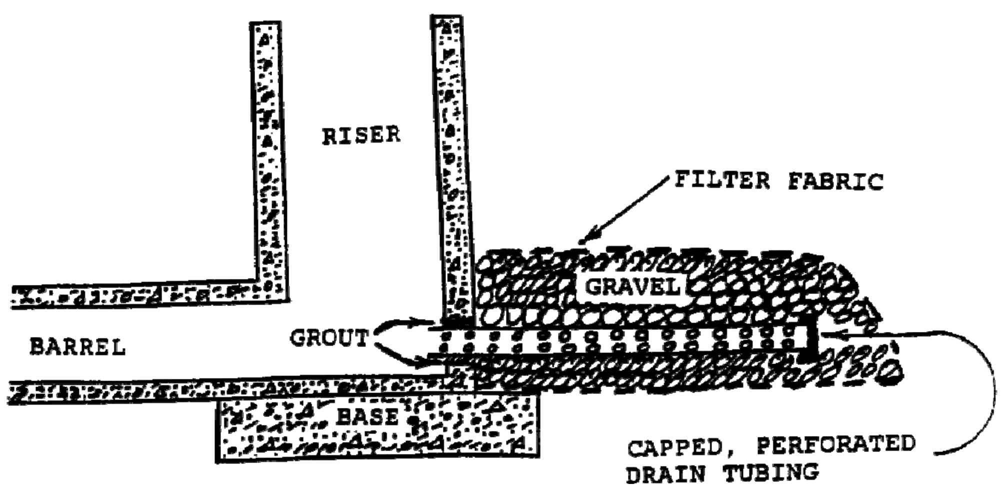


1. Steel frame shall be curved to fit the riser with no gap exceeding 1/3 inch. Sealant (asphalt or equivalent) shall be applied between the concrete and the frame.
2. Openings in the grating shall not exceed ½ the diameter of the orifice.
3. Where cage height equals or exceeds 4 feet, a 3' x 2' hinged gate with a locking mechanism shall be installed on the front face of the cage.

10.12 Appendix 12 Modifying Stormwater Detention Ponds to Serve Temporarily as Sediment Basins

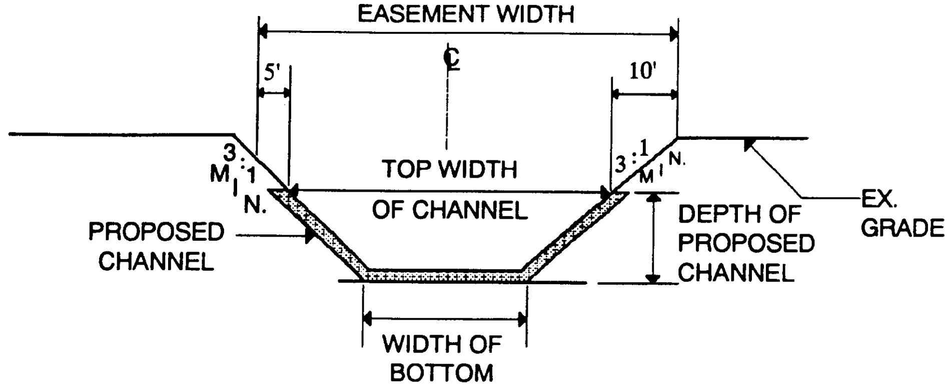
Most stormwater detention ponds are designed to serve temporarily as sediment basins. These ponds are installed before land clearing in other areas is begun. The volume of storage is based upon stormwater detention requirements rather than a fixed number cubic yards of wet and dry storage capacity per acre of disturbed land or drainage area. Although such structures generally have significantly less capacity than sediment basins, we feel that the advantages outweigh this decrease in capacity. Advantages include the “dry” storage provided to trap sediment before any significant amount of water leaves the pond. Another is that the pond can be constructed in accordance with the final, permanent design rather than constructing it in accordance with a temporary design and then modifying it to meet the design requirements for the permanent structure.

This modification is accomplished by placing filter fabric on the ground and placing 6-12 inches of gravel on top of the filter fabric. Perforated drain tubing or perforated pipe is laid on the gravel and temporarily grouted into the orifice. This can be done with brick and mortar or some form of impermeable grout which can be removed without damaging the orifice. The end of the tubing or pipe is capped and the tubing or pipe is covered with 12-18 inches of gravel. Size of gravel is not critical if it is properly enclosed in filter fabric but numbers 7, 8, and 78 are recommended. The filter fabric is then folded around the gravel so that water must flow through the fabric before flowing through the gravel. Where drainage area is 5 acres or less, a 20-foot length of tubing or pipe is recommended. Where drainage area exceeds 5 acres, it is recommended that the tubing or pipe be so designed that design drawdown time does not exceed 48 hours.

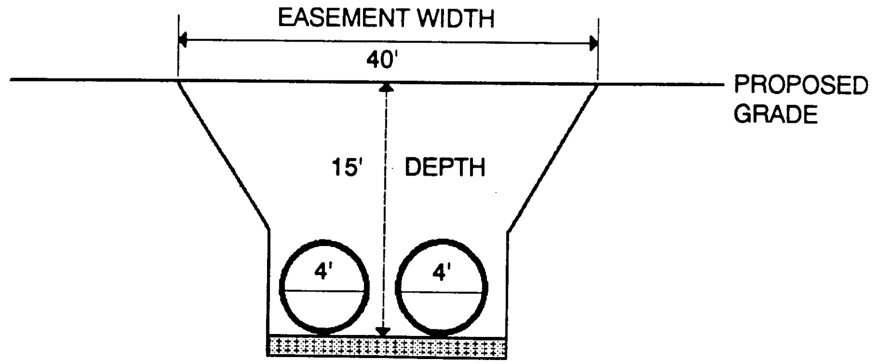


10.13 Appendix 13 Easement Width

STORMWATER CONVEYANCE CHANNEL



STORM SEWER



EXAMPLE: 4' DUAL PIPES AT 15' DEPTH

EASEMENT = 25' + 10' + 5' = 40'

Adapted from Prince George's County, MD Stormwater Management Design Manual

10.14 Appendix 14 As-Built Plan Checklist

10.14.1 Stormwater Conveyance Channels

A. Minimum Information

____ 1. Invert elevations and top of bank elevations, side slopes at cross section locations

____ 2. Type and class of materials

____ 3. Size and depth of rip-rap, and specify that it has been underlain by filter fabric

____ 4. Type and condition of vegetation

____ 5. Location of channel

B. Acceptable Construction

____ 1. Shape of channel must be consistent with design plan

____ 2. Capacity of channel must be no less than design plan capacity

____ 3. Materials must be consistent with design plan

____ 4. All channels shall be located correctly

10.14.2 Storm Sewers and Culverts

A. Minimum Information

____ 1. Diameter and type/class of all pipe

____ 2. Invert elevations of pipe at all entrances, outfalls, and structures

____ 3. Slope of pipe

____ 4. Pipe lengths

____ 5. Location of all pipe and structures

____ 6. Type of structures, including throat width

____ 7. Elevation of structure top

____ 8. Types of material

____ 9. Length, width and depth of all riprap and other outlet protection

____ 10. Ground elevations over pipe where depth of cover might exceed allowable maximum cover depths

B. Acceptable Construction

____ 1. Pipe diameter and elevations must be correct

____ 2. Structure dimensions and elevations must be correct
____ 3. All pipes and structures shall be located correctly
____ 4. Proper bedding and backfill of pipes and structures
____ 5. Materials must be consistent with design plan
____ 6. Outlet protection shall be adequate

10.14.3 Retention and Detention Ponds

A. Minimum Information

____ 1. Profile of top of dam. Elevations at each end, intervals not to exceed 50 feet and where low points are evident
____ 2. Cross section of emergency spillway at control section
____ 3. Profile along centerline of emergency spillway
____ 4. Width and shape of emergency spillway entrance channel, control section (all four corners) and exit channel, size and depth of rip-rap, and specify that rip-rap has been underlain by filter fabric
____ 5. Elevation of principal spillway crest, inlet and outlet
____ 6. Cross section of dam through principal spillway
____ 7. Riser diameter/dimensions and riser base size
____ 8. Type of materials used
____ 9. Barrel diameter, length and slope
____ 10. Outfall protection including size and depth of rip-rap and specify that it has been underlain by filter fabric
____ 11. Location, size and number of anti-seep collars
____ 12. Type and dimensions of anti-vortex and trash rack device
____ 13. Shape and elevations of all orifices and weirs
____ 14. Length, width and depth of ponds and contours of pond bottom
____ 15. Core trench depth and types of materials
____ 16. Size of stone, type of filter fabric, and tubing of toe drain/blanket drain
____ 17. Location, dimensions and materials of any liners
____ 18. Geotechnical Inspections Report
____ 19. As-built topography and computation of all designed storage volumes

B. Acceptable Construction

____ 1. Pipe diameter, length, material and elevations must be correct

____ 2. Area of orifices correct

____ 3. Trash rack, anti-vortex device, number of anti-seep collars are correct

____ 4. Emergency spillway may be 1-2% steeper, but no flatter or narrower than design. Located and aligned as shown on approved plans

____ 5. Embankment top elevation must be no less than design elevation plus allowance for settlement

____ 6. Riser size correct

____ 7. Top width of dam and pond side slopes must meet design

____ 8. Must have proper relation in elevation between principal spillway crest, emergency spillway crest and top of dam

____ 9. Outlet protection as per design plan

____ 10. Pond storage volume at the water quality pool, 1-year, 2-year and at the 10-year storm design elevations must be equal to or greater than volume on approved design plans

10.14.4 Bioretention and Biofilter Facilities

A. Minimum Information

____ 1. Plan and profile views of facility drawn to scale

____ 2. Elevation of principal spillway crest, inlet and outlet

____ 3. Profile view of principal spillway with all dimensions shown

____ 4. Type of materials used

____ 5. Shape and elevations of all orifices and weirs

____ 6. Elevation at top of all layers of materials used and materials used for any liners

____ 7. For bioretention facilities, geotechnical report indicating infiltration rates

____ 8. Number, type, and location of plantings

____ 9. Undisturbed subsoil measured infiltration rate (for bioretention facilities)

____ 10. Photographs documenting construction and showing: the site before beginning construction; the excavation’s undisturbed walls and bottom before any backfill; placement of each material layer showing the final top surface of each layer; placement of the underdrain system; and, outlet works.

B. Acceptable Construction

____ 1. Material types and top elevations correct

____ 2. Area of orifices correct

____ 3. Appropriate underdrain design

____ 4. Must have proper relation in elevation between principal spillway crest, emergency spillway crest and top of dam

____ 5. Outlet protection as per design plan

____ 6. Pond storage volume at the water quality pool, 1-year, 2-year and at the 10-year storm design elevations must be equal to or greater than volume on approved design plans

10.14.5 Underground Detention Systems

A. Minimum Information

____ 1. Size of all pipes

____ 2. Elevation and slope of all pipes

____ 3. Elevation and size of all orifices

____ 4. Elevation and thickness of weir walls

____ 5. Location and elevation of manholes

____ 6. Types of material

____ 7. Location of structure

____ 8. Geotechnical Inspections Report

B. Acceptable Construction

____ 1. Pipe diameter, elevation and materials must be correct

____ 2. Proper bedding and backfill of pipe and structures

____ 3. Dimensions and elevations of structures must be correct

____ 4. Location of structure correct

10.14.6 Infiltration Trenches

A. Minimum Information

____ 1. Type of materials
____ 2. Location of trench
____ 3. Dimensions and elevations
____ 4. Location and invert elevation of monitoring well
____ 5. Elevation of bedrock and groundwater
____ 6. Geotechnical Inspections Report

B. Acceptable Construction

____ 1. Pipe diameters and elevations must be correct
____ 2. Infiltration material as per design plans
____ 3. Dimensions and elevations of trench must be correct
____ 4. Monitoring well must be correct
____ 5. Bottom of trench a minimum of four feet above bedrock or seasonal water table
____ 6. Soil permeability acceptable

10.14.7 Other Types of Facilities

As-built plans shall provide necessary information to demonstrate that the facility as it is built conforms with all specifications and requirements of the approved design plan. As-built checklists for other types of SWM facilities are available in the Virginia Stormwater Management Handbook (Chapter 3 Appendix).

10.15 Appendix 15 Maintenance Agreement for Stormwater Management System

MAINTENANCE AGREEMENT
For
STORMWATER MANAGEMENT SYSTEM

This Agreement is entered into this ______ day of ________________, ____________, by and between ____, hereinafter referred to as the "Landowner" and the Board of Supervisors of Culpeper County, Virginia, hereinafter referred to as "County".

WITNESSETH:

WHEREAS, the Landowner has submitted a development plan for a project known as ____, which includes, among other features, a system that regulates peak rates of discharge and/or quality of runoff water (the term "system" includes any and all components designed to regulate flow, provide storage for runoff water, remove pollutants from runoff water and increase infiltration of runoff water into the soil); and

WHEREAS, the Landowner will install the system in order to comply with one or more of the following laws, regulations and codes:

Act	Regulations	Title
10.1-603	4 VAC 3-20-10, et seq.	Stormwater Management
10.1-560	9 VAC 50-30, et seq.	Erosion and Sediment Control

Culpeper County Code	Title of Ordinance
Article 11A.	Stormwater Management
Chapter 8	Erosion and Sediment Control

WHEREAS, this system includes____
____
____

WHEREAS, it is in the best interests of both parties and the general public to ensure proper maintenance of the system; and

WHEREAS, a maintenance plan (Attachment ____) for the system has been submitted by the Landowner and approved by the County in conjunction with this Agreement; and

Tax Map/Parcel(s) Number_________________________________

WHEREAS, both parties desire to ensure sufficient maintenance to maintain the integrity and the proper functioning of the system;

NOW, THEREFORE, for and in consideration of the mutual covenants stated below, the parties agree as follows:

1. The County shall:

A. Release construction security after as-built plans and other appropriate certifications, showing adequate completion of the system, have been submitted and approved by the County and after an inspection report prepared by County staff recommends approval of the system. The certification shall be made by a Professional Engineer (or a qualified Class B surveyor or certified Landscape Architect) and shall certify that the as-built plan represents the actual condition of the structure(s) and shows that all aspects of the structure(s) conform substantially with the approved design plans and the Culpeper County Stormwater Management Design Manual. Where the as-built condition varies significantly from the approved design, appropriately revised calculations shall also be provided by the professional certifying the system.

B. Perform maintenance inspections and provide copies of the maintenance inspection reports to the Landowner. These inspections will be performed at reasonable times (between 8 A.M. and 4:30 P.M., Monday through Friday) and with the Landowner or agent(s) of the Landowner, if available. Periodic inspections may be conducted after storms producing high rates of runoff. Whenever possible, the County shall notify the Landowner prior to entering the property.

2. The Landowner shall:

A. Construct the system in accordance with approved designs. Provide as-built data and drawings, soil/geotechnical reports, and other certifications requested by the County in order to document compliance with the approved designs and the requirements set forth in Culpeper County's Stomwater Management Design Manual.

B. Provide maintenance, which keeps the system in good working order acceptable to the County. Such maintenance shall be provided in perpetuity unless and until both parties formally enter into a revised agreement. Maintenance inspections will be performed within twenty-four (24) hours after each rainfall of one (1) inch or more.

C. Provide a right of ingress and egress for the County and agents of the County for maintenance inspections and, if deemed by the County to be needed and not adequately done by the Landowner within a reasonable time after due notice, maintenance and repair of the system. Thirty (30) days shall normally be regarded as a reasonable time. The Landowner will reimburse the County for maintenance and repair costs within ten (10) working days after receiving a request for reimbursement. It is expressly understood and agreed that the County is under no obligation to maintain or repair said system, and in no event shall this Agreement be construed to impose any such obligation on the County.

However, if the County performs or otherwise provides maintenance and/or repair, the Landowner will hold harmless and indemnify the County with regard to damage to or destruction or personal or real property.

D. Keep written records of inspections and repairs and provide access to those records to the County upon request.

E. Record this Agreement in the land records of Culpeper County along with a copy of the approved maintenance plan. The Landowner also stipulates, by the Agreement, that final plats for any and on which this system and/or a portion of this system is situated will include a reference to this Agreement and to its location (deed book designation, page number, etc.) in the land records of Culpeper County.

F. Agree that the terms of this Agreement shall be binding upon the heirs, successors and assigns of the Landowner and that any subsequent owner of the property shall be responsible for the maintenance of the system and shall hold the County harmless from any loss, damage, injury, cost or other claim resulting from the operation of the subject system.

G. Agree that for any systems to be maintained by a property owner's association, deed restrictions and covenants will include membership in a property owner's association responsible for providing maintenance of the system.

WITNESS THE FOLLOWING SIGNATURES:

DEVELOPER/OWNER:

NAME: ______________________

TITLE: ______________________

ADDRESS ________________

____

____

BY: ______________________

COMMONWEALTH OF VIRGINIA
COUNTY OF CULPEPER, to wit:

The foregoing Agreement was acknowledged before me this _____day of ________, 20 ____, by ____, developer/owner.

My commission expires: __________________

____
Notary Public

BOARD OF SUPERVISORS OF CULPEPER COUNTY, VIRGINIA

By: ______________________________
John Egertson
Planning Director

COMMONWEALTH OF VIRGINIA
COUNTY OF CULPEPER, to wit:

The foregoing Agreement was acknowledged before me this_____day of________,20____, by
John Egertson, Planning Director on behalf of the Board of Supervisors of Culpeper County, Virginia.

My commission expires: __________________

____
Notary Public

Approved as to form: ____
Culpeper County Attorney

10.16 Appendix 16 Sample Maintenance Plan for Stormwater Detention Ponds

1) Describe the structure and the site it serves. Also describe the design functions. Example: "This structure is a stormwater detention pond; it will store water during period of high intensity rainfall. Within a few hours most of the water will drain out of the pond. The development of Sections 1, 2, and 3 of subdivision"x" increased the amount of rainfall water which leaves the site because absorbent soil was covered with impervious surfaces such as building and roads. The purpose of this temporary storage is to ensure that the peak rates of flow to the channel below the subdivision were not increased. Such increases cause flooding and channel erosion downstream from the pond. This structure was also designed to be a Best Management Practice. In other words, it was designed to ensure that the amount of phosphorus and other pollutants flowing to the Rappahannock River were not increased by construction of Sections 1, 2, and 3 of subdivision "x". This is accomplished by holding some of the water for a longer period of time. The water from this BMP pool will drain out in about 48 hours after the detention pool has drained."

   The pond has a 36-inch reinforced concrete pipe (RCP), called a "barrel", through the bottom of the pond. In the pond there is a vertical RCP called a "riser." The small 4-inch hole in the bottom of the riser is called a "BMP orifice." The bottom of the 12-inch hole is 4 feet higher than the BMP orifice; the 4 feet of water stored in the bottom of the pond is the "BMP pool." The top of the riser is 7 feet above the bottom of the 12-inch hole. During the 10-year storm the water level would be about 1 foot above the top of the riser and the surface area of the water would be about ½ acre. There is also an emergency spillway on the left(facing downstream) end of the dam; during high intensity storms, water will also flow in this channel.

2) Mowing. All grasses should be mowed at least twice each year. Grasses such as tall fescue should be mowed in early summer after emergence of the heads on cool season grasses. They should be mowed again in the early fall to prevent seeds of annual weeds from maturing. Mowing of legumes such as Sericea lespedeza and crown vetch can be permitted to grow on the dam or in any part of the emergency spillway.

3) Liming and fertilizing. The soil should be sampled according to recommended procedures at least once every 4 years. The sample should be tested at a qualified soil testing laboratory (such as the one at VPI&SU). Lime and fertilizer should be applied in accordance with recommendations based on the tests.

4) Replanting and overseeding. If vegetation covers less than 40% of the soil surface, lime, fertilize and seed in accordance with current recommendations for new seedings. If vegetation covers more than 40% but less than 70% of the soil surface, lime fertilize and overseed in accordance with current recommendations.

5) Removing trash and debris. Trash, litter and vegetation will be removed as needed to prevent obstruction to the flow of water, to prevent movement of trash and litter to downstream properties, to maintain the integrity of the structure, to provide an attractive appearance and to minimize water pollution.

6) Removing sediment. Soil materials (including clay, silt, sand and gravel) will be removed before the detention pool or the BMP pool loses 10% of the designed storage capacity. If forebays are included in the design, sediment should be removed before the forebay loses 10% of the design capacity of the forebay.

7) Sediment disposal. Sediment disposal should be in accordance with current procedures for disposal of sediment. Where deemed necessary or desirable, the sediment will be tested for appropriate pollutants before it is removed from the pond.

8) Repairs, Repair slides, slumps and eroded areas promptly and in a workmanlike manner Trash racks, pipes, headwalls, etc. will be maintained, repaired and/or replaced as needed to maintain the integrity of the structure. Exposed metal surfaces will be painted to minimize damage due to rust.

9) Maintenance inspections. A representative of the owner(s) will inspect each stormwater management structure after each significant rainfall. Upon completion, the applicant is responsible for certifying that the completed project is in accordance with the approved plans and specifications (refer to the As-built checklist) and shall provide regular inspections sufficient to adequately document compliance. All inspections shall be documented and written reports prepared that contain the following information:

    a. The date and location of the inspection;

    b. Whether construction is in compliance with the approved stormwater management plan;

    c. Variations from the approved construction specifications; and

    d. Any violations that exist.

All such reports shall be submitted to the Culpeper County Planning Department.

All maintenance costs will be borne by the owner(s). Where structures are to be maintained by more than one party, allocation of costs will be in accordance with terms set forth in the maintenance agreement. Keys to locked access points shall be available to Culpeper County personnel upon request.

10) Maintenance records. The landowner, or someone designated by the landowner, shall inspect the detention pond within 24 hours after each rainfall event of one inch or more of rain. The owner or the designee shall keep written records of these inspections. The records shall also include maintenance and repairs performed. Copies of these records shall be provided to the county upon request.

11) System Failure. In case of failure of the pond, the landowner, or someone designated by the landowner, shall undertake repairs to return the pond to an operative condition.

12) The detention pond shall not be modified in any way without prior approval by Culpeper County Zoning Administrator.

10.17 Appendix 17 Sample Maintenance Plan for Stormwater Retention Ponds

1) Describe the structure and the site it serves. Also describe the design functions and provide information needed for proper maintenance. Example:

   This structure is a stormwater retention pond; one of its functions is to store additional water during periods of high intensity rainfall. Within a few hours most of this extra water will drain out of the pond. The development of Sections 1, 2, and 3 of subdivision "x" increased the amount of rainfall water which leaves the site because absorbent soil was covered with impervious surfaces such as buildings and roads. The purpose of this temporary storage is to ensure that the peak rates of flow to the channel below the subdivision were not increased. Such increases cause flooding and channel erosion downstream from the pond. This structure was also designed to be a Best Management Practice (BMP). In other words, it was designed to ensure that the amount of phosphorus and other pollutants flowing to the Rappahannock River were not increased by construction of Sections 1, 2, and 3 of subdivision "x". This is accomplished by storing a certain volume of water in the permanent pool.

   The pond has a 36-inch reinforced concrete pipe (RCP), called a "barrel," through the bottom of the pond. In the pond there is a 72-inch vertical RCP called a "riser." During the 10-year storm, the water level would be about 2 feet above the top of the riser and the surface area of the water would be about ¾ acre. There is also an emergency spillway on the left (facing downstream) and of the dam; during high intensity storms water will also flow in this channel.

   There is also a "forebay" at the inlet end of the pond; this is an area designed to trap coarse sediments before they go into the deeper water where sediment removal is more difficult and expensive.

   The permanent pool has a surface area of ½ acre (about 22,000 square feet). The volume of water in the permanent pool is 1.3 acre feet (about 490,000 gallons or 4 million pounds) of water. The average depth is about 3 feet; the maximum depth is about 7 feet. The area of land which drains to the pond is 8 acres. This information should be considered when making management decisions with regard to fish, control weeds, etc. This pond should be well suited for warm water fish such as bass; it is not well suited for cold water fish such as trout or land-locked salmon.

2) Mowing. All grasses should be mowed at least twice each year. Grasses such as tall fescue should be mowed in early summer after emergency of the heads on cool season grasses. They should be mowed again in the

early fall to prevent seeds of annual weeds from maturing. Mowing of legumes such as Sericea lespedeza and crown vetch can be less frequent. Trees and shrubs should not be permitted to grow on the dam or in any part of the emergency spillway.

3) Liming and fertilizing. The soil should be sampled according to recommended procedures at least once every 4 years. The sample should be tested at a qualified soil testing laboratory (such as the one at VPI&SU). Lime and fertilizer should be applied in accordance with recommendations based on the tests.

4) Replanting and overseeding. If vegetation covers less than 40% of the soil surface, lime, fertilize and seed in accordance with current recommendations for new seedings. If vegetation covers more than 40% but less than 70% of the soil surface, lime fertilize and overseed in accordance with current recommendations.

5) Removing trash and debris. Trash, litter and vegetation will be removed as needed to prevent obstruction to the flow of water, to prevent movement of trash and litter to downstream properties, to maintain the integrity of the structure, to provide an attractive appearance and to minimize water pollution.

6) Removing sediment. Soil materials (including clay, silt, sand and gravel) will be removed from the forebay before 25% of the capacity of the forebay is lost. Sediment will be removed from the rest of the pond before 10% of the designed storage capacity is lost in order to ensure that the pond will adequately function as a BMP. The plan includes information designed to facilitate sediment surveys; this includes a method for locating specific points in the pond and the forebay.

7) Sediment disposal. Sediment disposal should be in accordance with current procedures for disposal of sediment. Where deemed necessary or desirable, the sediment will be tested for appropriate pollutants before it is removed from the pond.

8) Repairs. Repair slides, slumps and eroded areas promptly and in a workmanlike manner. Trash racks, pipes, headwalls, etc will be maintained, repaired and/or replaced as needed to maintain the integrity of the structure. Exposed metal surfaces will be painted to minimize damage due to rust.

9) Maintenance inspections. A representative of the owner(s) will inspect each stormwater management structure after each significant rainfall. Upon completion, the applicant is responsible for certifying that the completed project is in accordance with the approved plans and specifications (refer to the As-built checklist) and shall provide regular inspections sufficient to adequately document compliance. All inspections

shall be documented and written reports prepared that contain the following information:

e. The date and location of the inspection;

f. Whether construction is in compliance with the approved stormwater management plan;

g. Variations from the approved construction specifications; and

h. Any violations that exist.

All such reports shall be submitted to the Culpeper County Planning Department.

All maintenance costs will be borne by the owner(s). Where structures are to be maintained by more than one party, allocation of costs will be in accordance with terms set forth in the maintenance agreement. Keys to locked access points shall be available to Culpeper County personnel upon request.

10) Maintenance records. The landowner, or someone designated by the landowner, shall keep written records of all inspections, maintenance and repairs performed. Copes of these records shall be provided to the county upon request.

11) System Failure. In case of failure of the pond, the landowner, or someone designated by the landowner, shall undertake repairs to return the pond to an operative condition.

12) The pond shall not be modified in any way without prior approval by the Culpeper County Zoning Administrator.

10.18 Appendix 18 Sample Maintenance Plan for Subsurface Stormwater Detention Systems

1) Describe the structure and the site it serves. Also describe the design functions and provide information needed for proper maintenance. Example:

   This structure will store water during high-intensity rainfall. Most of the water will drain out within a few hours. The development of the Shopping Center "x" increased the amount of rainfall water which leaves the site because absorbent soil was covered by the building and the paved parking lot. The purpose of this temporary storage is to ensure that the peak rates of flow to the channel below the shopping center were not increased.

   The control structure is a large concrete box with a wall across the middle. There is a 6-inch hole (called an "orifice") in the bottom of the wall. The western end of this box is connected to a concrete pipe 48 inches in diameter and about 300 feet long. When there is more water coming in than the 6-inch hole can carry, the extra water is stored in the western side of the box and in the 48-inch pipe. During very high intensity storms the water flows over the top of the wall (when water flows over the wall, it serves as a "weir). This weir is designed to prevent flooding of the parking lot. The wall on the eastern end of the box is connected to an 18-inch concrete pipe. This carries the water which flowed through the orifice and over the weir to a channel near Parkway "x". Each side of the control box is accessible through a manhole cover. Four more manhole covers also provide access to the storage pipe.

2) Maintenance inspections. A representative of the owner will inspect the control box and the storage pipe after each significant rainfall. If water is standing in both compartments of the control structure more than 5 hours after the rain has stopped, check the outlet end of the 18-inch pipe. If it is not obstructed, check the inlet end in the eastern end of the control structure; it is recommended that no one enters the control structure when water is standing in the structure unless another adult is standing by outside the structure. While not common in storm sewer structures, it is possible that heavier-than-air gases could be trapped above the water; this is not likely if the water has drained out since the heavy air would also drain out through the 18-inch pipe unless the outlet end of the pipe is submerged in water. If only the western compartment contains standing water, the 6-inch hole in the weir/orifice wall is probably plugged. This is the maintenance problem which is most likely to occur other than simply cleaning up litter. Workers can usually clear this opening while in the eastern compartment. Once each year a representative of the owner will

inspect the entire detention system. Appropriate action will be taken to ensure proper maintenance. All maintenance costs will be borne by the owner(s). Keys to locked access points shall be available to Culpeper County personnel upon request.

3) Removing trash, debris and sediment. The control structure and the pipe should also be checked during dry weather. Litter and sediment deposits should be removed as needed to prevent obstruction to the flow of water, to prevent movement of trash and debris to downstream properties, to minimize water pollution and to ensure that the system adequately performs the function for which it was constructed.

4) Sediment disposal. Sediment disposal should be in accordance with current procedures for disposal of sediment. Where deemed necessary or desirable, the sediment will be tested for appropriate pollutants before final disposal.

5) Property maintenance. Grass and other soil covers should be maintained in order to minimize the amount of sediment entering the system. Trash and litter should be collected on a daily basis.

6) Maintenance records. The owner, or someone designated by the owner, shall keep written records of all inspections. The records shall include maintenance and repairs performed. Copies of these records shall be provided to the county upon request.

7) System Failure. In case of failure, the landowner, or someone designated by the landowner, shall undertake repairs to return the system to an operative condition.

8) The system shall not be modified in any way without prior approval by the Culpeper County Zoning Administrator.

10.19 Appendix 19 Sample Maintenance Plan for Stormwater Infiltration Systems

1) Describe the structure and the site it serves. Also describe the design functions. Example:

   This stormwater infiltration system will store runoff water for a period of about 48 hours after heavy rainfall. The development of "X" Mini-Mall increased the amount of rainfall water which leaves the site because absorbent soil was covered by the building and the paved parking lot. This increase in impervious area also increased the amount of pollutants carried by runoff water. This structure has two purposes. It is designed to ensure that the peak rates of runoff from the 2-year and 10-year storms were not increased by construction of Mini-Mall "x". It is also designed to ensure that the amount of phosphorus (a "keystone" pollutant) leaving the site in runoff water was not increased by construction of "X" Mini-Mall; this system is a Best Management Practice constructed in compliance with the Culpeper County Stormwater Management Ordinance and the VSMP.

   This structure is basically a trench filled with gravel. Water is stored in the voids (spaces between the pieces of gravel) until it seeps into the soil under the bottom of the trench. This decreases the amount of runoff and the water is added to other water stored in the ground ("groundwater"). The soil also serves as a filter. When larger storms occur, the overflow will be carried to the road ditch by a broad, shallow channel. The top 12 inches of gravel is underlain by a filter fabric which is wrapped around the rest of the gravel. There are also three observation wells; these are vertical plastic pipes with removable caps. There is a 20-foot wide strip of grass (filter strip) between the pavement and the trench. The purpose of this filter strip is to remove some of the particles which would otherwise plug holes in the gravel and the filter fabric.

2) Maintenance inspections. The observation wells should be checked right after rainfall has stopped or rainfall intensity has slowed down, If the trench is full of water runoff water is getting into the gravel. If the overflow channel carries water during the rainfall and the water level in the trench is relatively low, it is very likely that the holes in the top 12 inches of gravel and/or the holes in the filter fabric have been filled or plugged. When this happens, the top 12 inches of gravel and the filter fabric under the gravel should be replaced with clean materials.

   These factors will also vary with duration and intensity of rainfall; routine inspections should be done by the same person or persons in order to develop a base of knowledge about the system. The filter strip should also be inspected. Maintain a healthy stand of grass. Cut with lawnmowers at a high setting (grass should be at least 4 inches tall just after mowing) so the remaining grass can function as a filter. This grass should be bagged as it is mowed so that the cuttings will not plug up the holes in the gravel. The observation wells should also be inspected 2 to 3 days after the rain has stopped. If there is water in the bottoms of the wells it is probably time to remove all of the gravel and filter fabric and replace the filter fabric. If the gravel is dirty or dusty it too should be replaced. The system was designed to be several feet above the water table. However, if there is water in the wells 48 hours after rainfall in April and May but not in July and August, the standing water may indicate that the seasonal high water table was higher than anticipated; discuss this with appropriate Culpeper County personnel.

3) Removing trash, debris and sediment. The best was to remove sediment is to prevent it from being there. Do not allow areas of soil to be exposed to rain; plant grass or provide other ground cover. During winter, keep application of such things as sand and cinders to a minimum. Litter and sediment deposits should be removed, preferably before they get to the filter strip. If sediment deposits in the filter strip cause water to pond on the pavement, remove the sediment and the grass. Replace the grass with tall fescue sod or apply lime, fertilizer, seed and mulch and install a temporary silt fence along the edge of the trench. Collect trash and litter on a daily basis.

4) Sediment disposal. Sediment disposal should be in accordance with current procedures for disposal of sediment. Where deemed necessary or desirable, the sediment will be tested for pollutants before final disposal.

5) Maintenance records. The owner, or someone designated by the owner, shall keep written records of all inspections. The records shall include maintenance and repairs performed. Copies of these records shall be provided to the county upon request.

6) System Failure. In case of failure of the system, the landowner, or someone designated by the landowner, shall undertake repairs to return the system to an operative condition.

7) The system shall not be modified in any way without prior approval by the Culpeper County Zoning Administrator.

10.20 Appendix 20 Maintenance Plan for Bioretention Systems

1) Describe the structure and the site it serves. Also describe the design functions. Example:

   This bioretention system will store runoff water for a period of about 48 hours after heavy rainfall. The development of (*project name*) increased the amount of rainfall water which leaves the site because absorbent soil was covered less pervious materials than before development. This increase in impervious area also increased the amount of pollutants carried by runoff water. This structure has two purposes. It is designed to reduce peak rates. It is also designed to ensure that the amount of phosphorus (a "keystone" pollutant) leaving the site in runoff water is not increased by construction; this system is a Best Management Practice constructed in compliance with the Culpeper County Stormwater Management Ordinance and the VSMP.

   This structure is basically an excavation filled with layers of various backfill materials and with a depressed area on top where a defined volume of water can accumulate in a pond. Water is also stored in the voids within the backfill materials and seeps into the soil under the bottom of the excavation. This decreases the amount of runoff and the water is added to other water stored in the ground ("groundwater"). The soil also serves as a filter. When larger storms occur, the overflow will be carried away by (*describe any underdrain and outlet works*). There (*is*) (*are*) also (*an*) (*number*) observation well(s); these are vertical pipes with removable caps. There is also a (*number*)-foot-wide strip of grass (filter strip) between the pavement and the trench. The purpose of this filter strip is to remove some of the particles which would otherwise plug holes in the gravel and the filter fabric.

2) Maintenance inspections. The observation well should be checked right after rainfall has stopped or rainfall intensity has slowed down, If the well is full of water, runoff water is getting into the gravel. If the outlet works carries water during the rainfall and the water level in the well is relatively low, it is very likely that the holes in the backfill materials are becoming filled or plugged with sediment. When this happens, the backfill materials should be removed and replaced with clean materials.

   These factors will also vary with duration and intensity of rainfall; routine inspections should be done by the same person or persons in order to develop a base of knowledge about the system. The filter strip should also be inspected. Maintain a healthy stand of grass. Cut with lawnmowers at a high setting (grass should be at least 4 inches tall just after mowing) so the remaining grass can function as a filter. This grass should be bagged as it is mowed so that the cuttings will not plug up the holes in the gravel. Do not use the clippings as mulch in the pond. The observation wells should also be inspected 2 to 3 days after the rain has stopped. The system was designed to be significantly above the water table. However, if there is water in the wells 48 hours after rainfall in April and May but not in July and August, the standing water may indicate that the seasonal high water table was higher than anticipated. If this occurs, discuss this with appropriate Culpeper County personnel.

3) Removing trash, debris and sediment. The best way to remove sediment is to prevent it from being there. Do not allow areas of soil to be exposed to rain; plant grass or provide other ground cover. During winter, keep application of such things as sand and cinders to a minimum. Litter and sediment deposits should be removed, preferably before they get to the filter strip. If sediment deposits in the filter strip cause water to pond on the pavement, remove the sediment and the grass. Replace the grass with tall fescue sod or apply lime, fertilizer, seed and mulch and install a temporary silt fence along the edge of the trench. Collect trash and litter on a daily basis. Mulch layer should be inspected to ensure it is in good condition and near the original thickness. Mulch should be removed and replaced at least annually.

4) Sediment disposal. Sediment disposal should be in accordance with current procedures for disposal of sediment. Where deemed necessary or desirable, the sediment will be tested for pollutants before final disposal.

5) Maintenance records. The owner, or someone designated by the owner, shall keep written records of all inspections. The records shall include maintenance and repairs performed. Copies of these records shall be provided to the county upon request.

6) System Failure. In case of failure of the system, the landowner, or someone designated by the landowner, shall undertake repairs to return the system to an operative condition.

7) The system shall not be modified in any way without prior approval by the Culpeper County Zoning Administrator.

10.21 Appendix 21 Maintenance Plan for Biofilters

1) Describe the structure and the site it serves. Also describe the design functions. Example to be modified as appropriate:

   The Biofilters consist of surface landscaping a 2- to 3-inch mulch layer, approximately two feet of bioengineered soil media with a twelve-inch gravel sump, perforated underdrains are installed within the gravel sump to ensure proper drainage. The gravel sump consists of a 4- to 6-inch pea gravel layer above VDOT #57 stone. Filter fabric is placed on top of the pea gravel layer, extending 1- to 2-feet to either side of the underdrains. A low-flow orifice pipe is used to establish the water quality treatment volume. A stabilized overflow spillway will allow the runoff from larger storms to bypass the structure.

2) Maintenance inspections. The observation wells should be checked right after rainfall has stopped or rainfall intensity has slowed down, If the trench is full of water runoff water is getting into the gravel. If the overflow channel carries water during the rainfall and the water level in the trench is relatively low, it is very likely that the holes in the top 12 inches of gravel and/or the holes in the filter fabric have been filled or plugged. When this happens, the top 12 inches of gravel and the filter fabric under the gravel should be replaced with clean materials.

   These factors will also vary with duration and intensity of rainfall; routine inspections should be done by the same person or persons in order to develop a base of knowledge about the system. The filter strip should also be inspected. Maintain a healthy stand of grass. Cut with lawnmowers at a high setting (grass should be at least 4 inches tall just after mowing) so the remaining grass can function as a filter. This grass should be bagged as it is mowed so that the cuttings will not plug up the holes in the gravel. The observation wells should also be inspected 2 to 3 days after the rain has stopped. If there is water in the bottoms of the wells it is probably time to remove all of the gravel and filter fabric and replace the filter fabric. If the gravel is dirty or dusty it too should be replaced. The system was designed to be several feet above the water table. However, if there is water in the wells 48 hours after rainfall in April and May but not in July and August, the standing water may indicate that the seasonal high water table was higher than anticipated; discuss this with appropriate Culpeper County personnel.

3) Removing trash, debris and sediment. The best way to remove sediment is to prevent it from being there. Do not allow areas of soil to be exposed to rain; plant grass or provide other ground cover. During winter, keep application of such things as sand and cinders to a minimum. Litter and sediment deposits should be removed, preferably before they get to the

filter strip. If sediment deposits in the filter strip cause water to pond on the pavement, remove the sediment and the grass. Replace the grass with tall fescue sod or apply lime, fertilizer, seed and mulch and install a temporary silt fence along the edge of the trench. Collect trash and litter on a daily basis. Mulch layer should be inspected to ensure it is in good condition and near the original thickness. Mulch should be removed and replaced at least annually.

4) Sediment disposal. Sediment disposal should be in accordance with current procedures for disposal of sediment. Where deemed necessary or desirable, the sediment will be tested for pollutants before final disposal.

5) Maintenance records. The owner, or someone designated by the owner, shall keep written records of all inspections. The records shall include maintenance and repairs performed. Copies of these records shall be provided to the county upon request.

6) System Failure. In case of failure of the system, the landowner, or someone designated by the landowner, shall undertake repairs to return the system to an operative condition.

7) The system shall not be modified in any way without prior approval by the Culpeper County Zoning Administrator.

10.22 Appendix 22 Maintenance Plan for Delaware Sand Filters

The system consists of two parallel concrete trenches (long narrow concrete boxes) placed side by side. The wall between the two trenches contains rectangular openings through which water flows from the first trench to the second trench.

Water enters the trench nearest the paved area through grates in the cover over the trench. This trench is called a "sedimentation chamber". There is a relatively permanent pool of water in this chamber. This helps to prevent heavier particles from entering the filter chamber. As the depth of sediment increases, the depth of water decreases and the ability of this pool to remove pollutants decreases. This chamber should be cleaned out when the sediment reaches a depth of 4 inches. Cleaning is usually done with tank trucks equipped with vacuum pumps.

The second chamber contains the sand filter and is known as the filter chamber. This chamber has a solid cover since the water must first be treated by the sedimentation chamber. Pollutants (including fine particles and floatable materials such as hydrocarbons) will enter this chamber. Some of the pollutants are trapped on the sand or in the sand. The accumulated pollutants reduce the ability of the water to flow through the sand and the ability of the sand to trap more pollutants. It is therefore necessary to replace the sand occasionally with "ASTM C-33 Concrete Sand"; this sand should be at least 18 inches deep. The sand is underlain by perforated tubes or pipes. The tubes convey the treated water to a flow splitter/clearwell at the outlet end of the system.

Each chamber is about 3 ft wide and 36 ft long. There are 14 rectangular openings (16 inches wide and 3 inches high) in the wall between the two chambers. The bottoms of these openings are about 3.75 feet above the floors of the chambers. The water in the sedimentation chamber should drain down to the bottoms of these openings within 24 hours. The water in the filter chamber should drain out completely within 36 hours after the rain has stopped. If drawdown times exceed these guidelines and there are no obstructions in the outlet structure the sand and the geotechnical fabric should be removed and replaced. Check the perforated tubing before replacing the sand. This should normally be done once every 3 to 5 years. If removal is required more frequently, check for erosion in the area that drains to the sand filter. Stabilize eroding areas so that less sediment will flow to the structure.

Perform at least one major inspection each year. Check for missing grates, structural damage, cracks, etc. Keep a log of inspections (date, time, weather, depth of sediment in the sedimentation chamber and depth of water in both chambers, other items noted. etc.). Keep records of all maintenance and repairs. In case of failure of the system, the landowner, or someone designated by the landowner, shall undertake repairs to return the system to an operative condition.

Copies of these records shall be provided to Culpeper County upon request.

10.23 Appendix 23 Maintenance Plan for Dry Wells

One or more "dry wells" were installed in order to comply with Culpeper County's Stormwater Management Ordinance. Runoff from the roof must flow into the dry wells. These dry wells should fill up with water during heavy rainfall. There should be no water standing in the dry wells 48 hours after the rain has stopped. These wells have been designed to hold specific volumes of water until it infiltrates into the soil. If they function properly, the peak rates of runoff leaving the site will be reduced, pollutants will be removed by the filtering action of the soil and underground water supplies will be recharged.

In order for these wells to function properly, the owner is obligated to maintain them. The water should be able to get to the wells. Rainspouts should be kept clean. Remove such things as tree leaves, seeds and roof beads. Screens and wire trash racks can be helpful. The areas where the downspouts enter the plastic pipes should also be kept clean and open; the water should be able to come out here when the well is full. Each dry well has several observation wells (perforated vertical pipes). Each observation well has a removable (preferably lockable) cap. The observation wells should be checked at least once every three months. The check would consist of measuring the depth to water after heavy rainfall (if it is full, the water from the roof is getting into the well) and checking the depth to water two days later (if there is no water, it is infiltrating into the soil) The observation wells which receive water directly from rainspouts also contain cleaning rods. There is a cap (or plate) on the bottom end of each rod. Debris can be removed from an observation well by pulling the rod up and cleaning the cap. The rod should be reinstalled right after the debris has been removed from the cap.

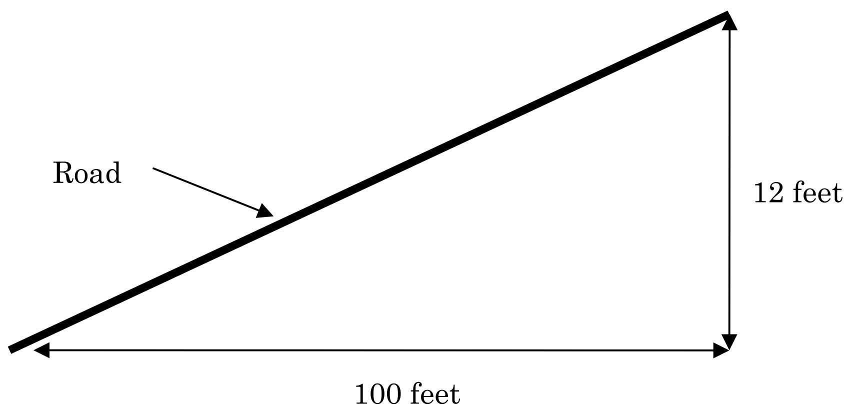
If properly maintained, the maintenance described above may be all that is needed. If the holes in the gravel become filled with dirt and/or other debris, it may be necessary to install new stone and filter fabric in the dry well. If "fines" fill the holes in the fabric to such an extent that water will not filter out within 48 hours, the filter fabric should be replaced. In case of failure of the system, the landowner, or someone designated by the landowner, shall undertake repairs to return the system to an operative condition.

10.24 Appendix 24 Stormwater Management Facility Access Requirements

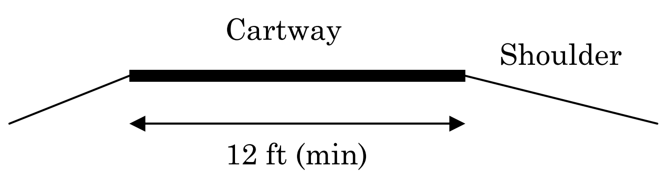
Access to a public route must be provided for stormwater management facilities.

10.24.1 Layout Requirements

Maximum (steepest) grade for access roads is 12% as illustrated below.

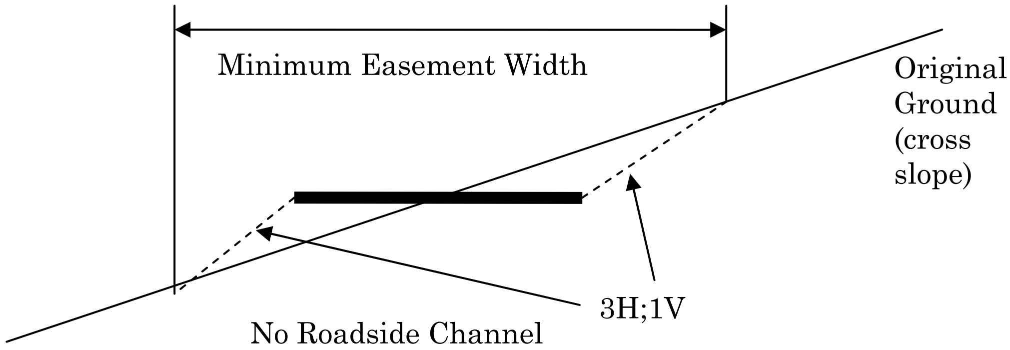


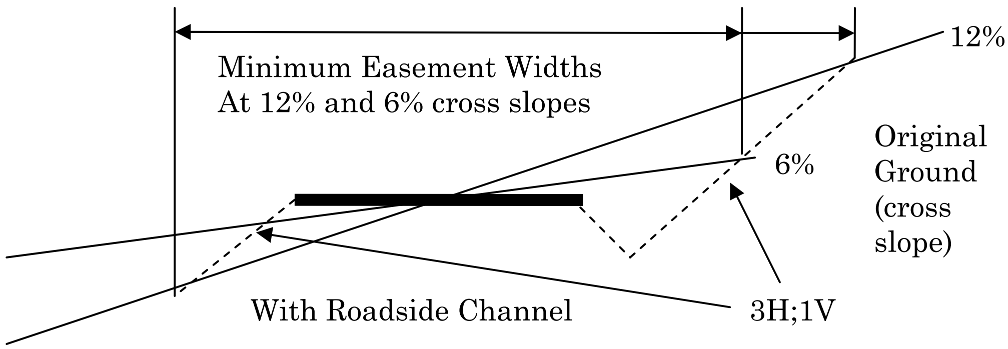
Minimum cartway width is 12 feet with any shoulders extending beyond the cartway as illustrated below.



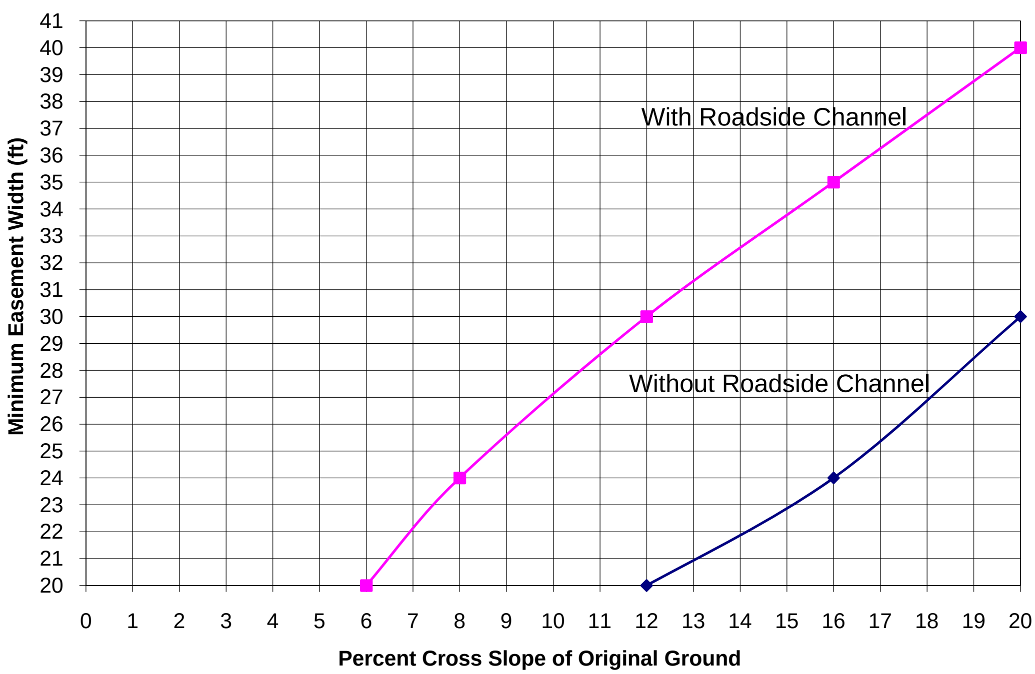
10.24.2 Easement Requirements

Minimum easement width is 20 feet if no road channel is needed and if the road is not crossing a slope steeper than 12%. Easements must include the full width of land needed to construct the road with the resulting slopes on each side no steeper than one foot of rise or fall in 3 horizontal feet. See the following illustrations.





As illustrated, the minimum easement width is a function of the cross slope of the original ground on which the road is built. Use the following chart to determine minimum easement widths for stormwater management access roads.



10.25 Appendix 25 Flood Hazard Overlay District Ordinance Implementation

The following is required to implement the requirements of Section 8A of the Culpeper County Zoning Ordinance.

10.25.1 Floodplain District (Zone AE)

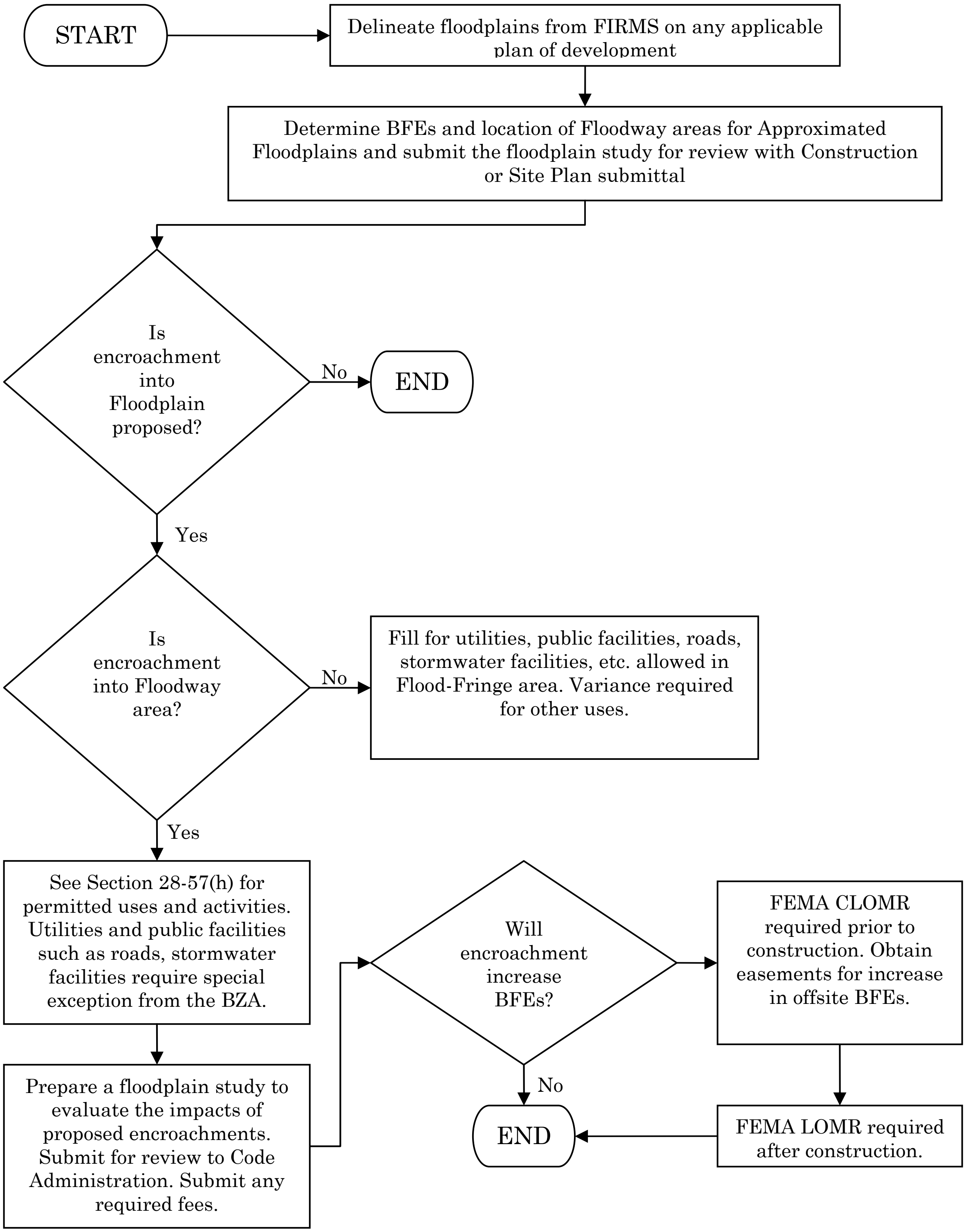
There are limited uses and activities permitted in the Floodway District (See Section 8A-5 *Permitted Uses* and 8A-5-2 *Special Uses* of the Culpeper County Zoning Ordinance). Public facilities such as roads, utilities, and water-dependent uses are permitted in floodways with the issuance of a Conditional Use Permit by the Board of Supervisors (BOS). The Zoning Administrator may issue an administrative exception for water depended uses, activities associated with tidal bodies of water, and certain shoreline protection measures. For any proposed use or activity in the floodway, the applicant will be required to submit a floodplain study to the Zoning Administrator demonstrating the impacts of the proposed encroachments on base flood elevations (BFEs). Encroachments that would result in any increase in base flood elevations are prohibited unless the applicant first obtains a conditional floodway revision (Conditional Letter of Map Revision) from the Federal Emergency Management Agency (FEMA).

10.25.2 Reserved

10.25.3 Approximated Floodplain District (Zone A Only)

For a proposed development located near an approximated floodplain, the applicant shall provide, as part of the plan of development review process, a floodplain study to identify the precise location of the floodway area, flood-fringe area, and associated base flood elevations. Development (i.e. encroachments) in the delineated floodway area shall be in accordance with the provisions of the Floodway District. Development in the flood-fringe area shall be in accordance with the provisions of the Flood-Fringe District.

The following is a chart depicting the floodplain review process.



10.26 Appendix 26 Interim Specification Using PVC Pipe and HDPE Pipe for Stormwater Installations

Whereas HDPE pipe is allowed to be used in commercial sites and residential driveways in Culpeper County, this specification is offered for use by the development community for the successful installation of PVC and HDPE products.

10.26.1 Materials

Materials used shall conform to the Standard Specification for 12-inch to 60-inch angular corrugated HDPE specification ASTM-F-2306-05 for S with soil tight joints.

Other Material allowed under this specification is A-2000 PVC pipe as manufactured for Contech Construction Products in standard sizes for 12-inch to 36-inch diameter. Where gasoline or petroleum products are going to be present, A-2000 PVC pipe can be used as a part of this specification.

10.26.2 Installation

Follow manufacturer's recommendation for laying the pipe. Note trench width shall not exceed one foot (1'-0") greater than the pipe outside diameter on each of the pipes.

Follow VDOT bedding details for Installation of Pipe Culverts and Storm Sewers. Circular Pipe Bedding and Backfill—Method "A".

Depth of bedding below the pipe to be a minimum of 4 inches.

Bedding to be tamped on both sides of pipe.

Bedding placement above pipe to a minimum depth of one foot (1'-0") above the top outside wall of the pipe.

10.26.2.1 Select Granular Material for Bedding.

Select granular material shall consist of well-graded sand, gravel, crushed stone or crushed slag composed of hard, tough and durable particles, and shall contain no more than 10 percent by weight of material passing the number 200 mesh sieve. The maximum allowable aggregate size shall be 1 inch, or the maximum size recommended by the pipe manufacturer, whichever is smaller.

10.26.3 Testing

Follow recommendations of the industry for mandrel testing for pipe sizes to 24 inches in diameter.

For pipe sizes 30 inches and greater, the deflection testing can be done from measurements obtained in the field. Video inspection on all storm sewer systems will be required prior to final construction approval.

Maximum deflection allowed during testing constructed 30 days or more after installation shall confirm the following: In deflection testing, the maximum allowable pipe deflection (which is reducing the vertical inside diameter) is 5 percent for pipe sizes to 24 inches and a maximum 7.5 percent for pipe sizes 30 inches and greater.

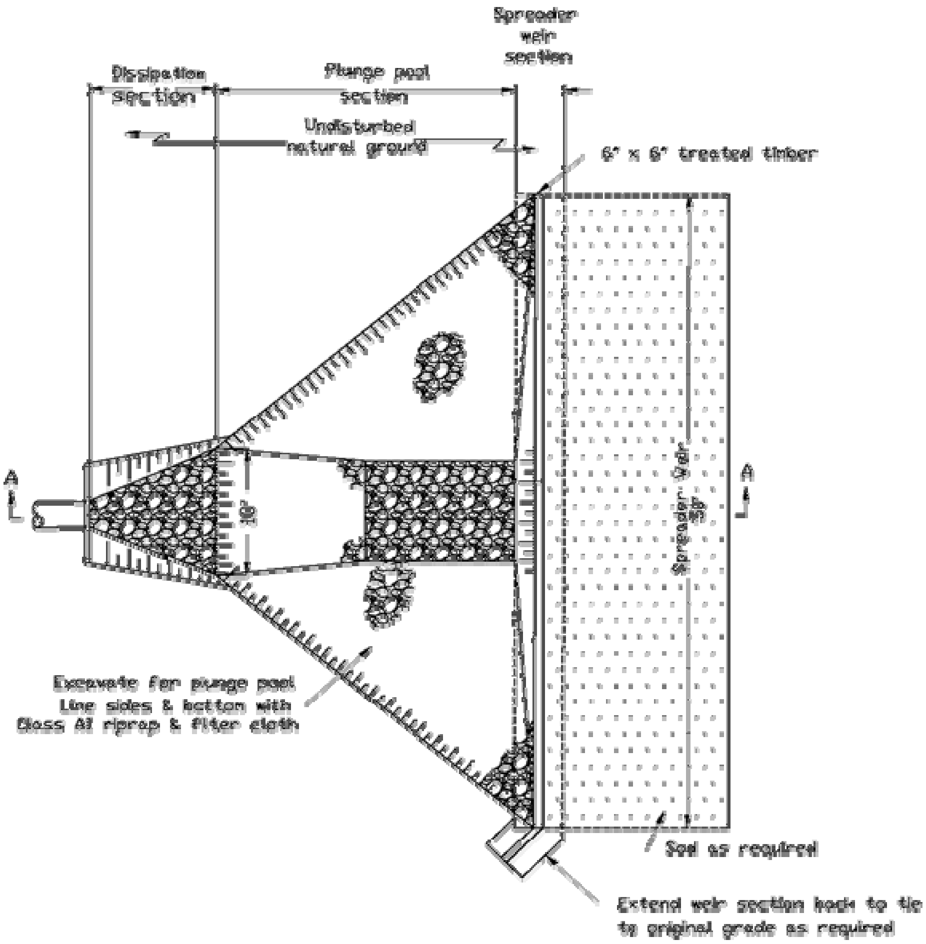
10.26.4 Certifications

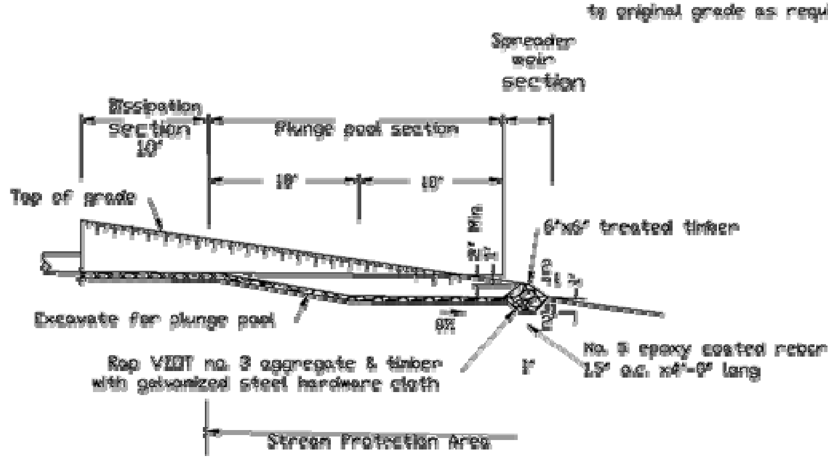
Provide manufacturer installation quality compliance certifications to Culpeper County that the pipe conforms to the material specification stated.

Delivery tickets to be given to field inspector for each load of aggregate bedding delivered to the jobsite.

10.27 Appendix 27 Level Spreader Details

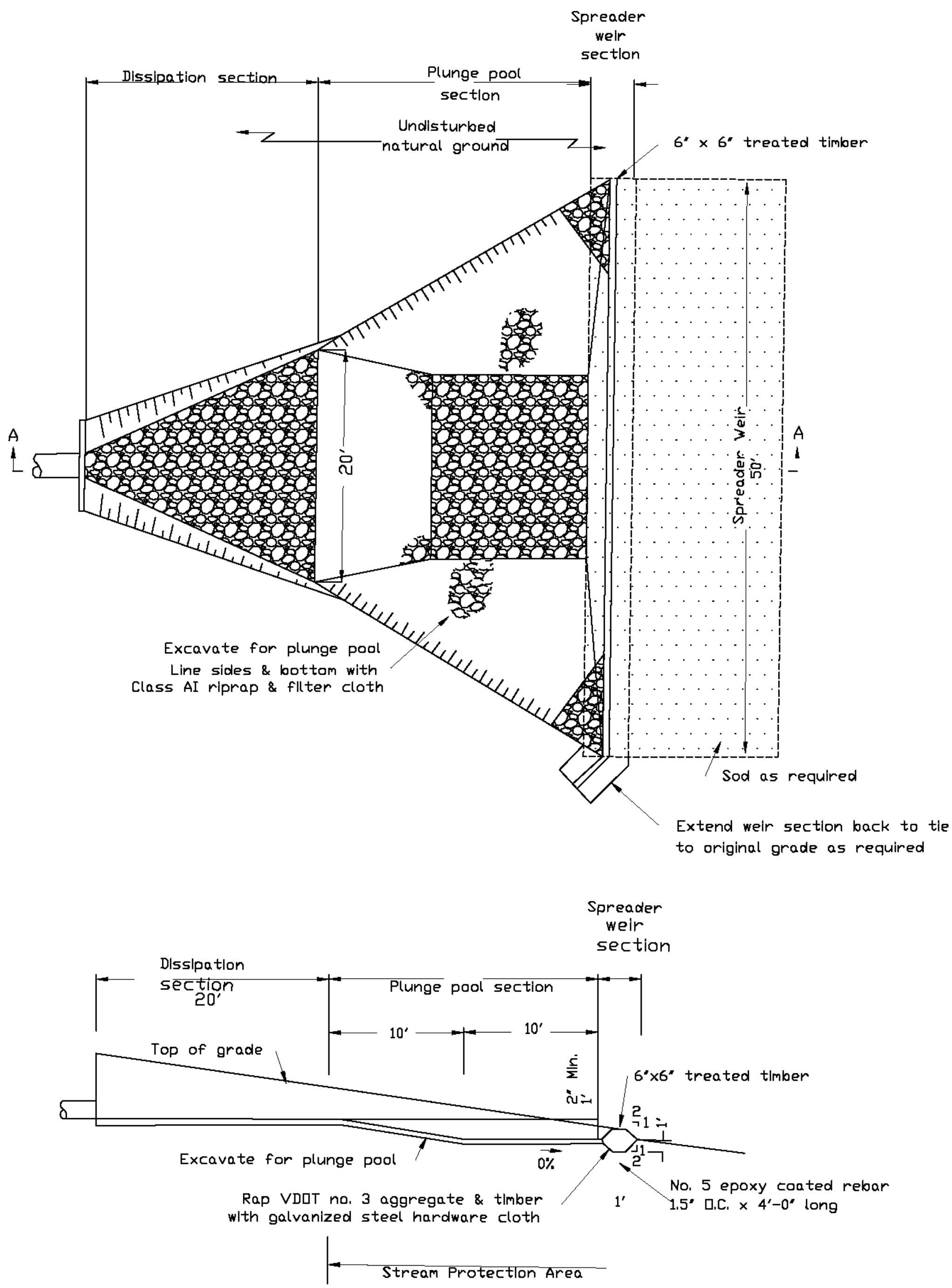
The following pages show detail drawings for level spreader devices. A level spreader is a device that is used to convert concentrated stormwater runoff into sheet flow and is constructed at the end of all storm sewers or channels that outfall into a buffer. The purpose of the level spreader is to introduce storm flows into the buffer at a slower rate and spread the flow over a larger area than would normally occur with a storm sewer outfall. This allows for more efficient use of the buffer by spreading the storm flow over a wider area of the buffer. More information may be found in Section 4.6.11.





Section AA

Storm Water Level Spreader Device
Design A
N.T.S.



Section AA

Storm Water Level Spreader Device
Design B
N.T.S.

10.28 Appendix 28 Procedural Guide to Stormwater Computations

Concept Stormwater Management Calculations (section 5.6)

***Natural Resource Assessment (Appendix 10.2.1)** identifies opportunities for preservation or conservation of vegetation, soils, slopes, and water bodies. This includes soil characteristics, critical slopes, old growth trees, streams, ponds, and wetlands.

***LID Checklist (Appendix 10.2.2)** identifies site constraints and design opportunities for reducing impervious surfaces, maximizing disconnection and dispersion, reducing impacts to existing water bodies, and the infiltration of the LID design storm and peak control of the 2-and 10-year design storms.

LID Computations addresses the LID Design Storm (1-year, 24-hour storm)

1. Select locations for integrated BMPs. Each BMP should have its own unique Drainage Area and that area must be within the design limits of the proposed BMP. Offline structures are preferred to allow bypass of larger storms.
2. Calculate Curve Number (CN)
   $CN_{pre(woods)}$ = Composite Curve Number under woods in good condition
   CN_{post} = Composite Curve Number for Post Development
3. LID Curve Number (CN_{LID})
   $CN_{LID} = CN_p + (P_{imp}/100)\ (98 – CN_p)\ (1\text{-}0.5R)$
   CN_p = Pervious Composite Curve Number for Post Development
   CN_{LID} = Composite Curve Number considering impervious disconnection
   P_{imp} = Percent Impervious Cover (Impervious Area / Total Drainage Area)
   R = Unconnected Impervious Area / Total Impervious Area
4. Determine Design Storm Retention and Detention Storage Volumes. Follow the Six (6) Step process outlined in Prince George's LID Hydrologic Analysis Manual. Step 7 may be required depending on site.
5. BMP Sizing for Retention and Detention Storage.
   a. Retention Volume = Ponding Depth * Surface Area
      i. Surface Area = Retention Volume / Ponding Depth (0.5 ft)
      ii. Volume Soil/Rock = Retention Volume / Porosity
      iii. Depth of Soil/Rock = Volume of Soil/Rock / Surface Area
   b. Double Credit – Surface and Underground Retention Storage works only for high porosity structures (0.4 or greater)
   c. Detention Volume = Detention Depth * Surface Area

i. See Final Stormwater Management Calculations to size outlet.
ii. Detention Depth = Detention Volume / Surface Area
iii. Detention Depth of the LID Design Storm should not exceed 2 inches above spillway.

6. Calculate the Pre-development Time of Concentration (T_{cpre}) for each drainage area. Calculate the Post-Development Time of Concentration (T_{cpost}). Each integrated BMP can disperse Concentrated Flow into Sheet Flow. If T_{cpost} does not equal T_{cpre} then integrate additional BMPs.
   a. Time of Concentration within integrated BMPs with Retention Volume:
      i. The following are two acceptable methods:
         1. For in-line structures, model the length of flow as shallow concentrated flow
            a. Use Watercourse Slope and Plate 5-2 in the VAESCH to determine velocity, fps
            b. Tt = L / (60 * v)
            c. Tt = travel time, minutes
            d. L = length of flow, feet
            e. v = velocity, fps
         2. For offline structures, use the retention storage volume and runoff rate.
            a. Tp = Retention Volume / Qi / 60
            b. Tp = time to pond, minutes
            c. Qi = Post peak runoff rate, cfs

Final Stormwater Management Calculations (section 6.11)

LID Computation Summary:

- BMP Drainage Area
- $CN_{pre(woods)}$ and CN_{LID}
- Retention Volume required and provided
- Detention Volume required and provided
- BMP Surface area
- BMP retention depth
- BMP detention depth

I. VSMP General Permit Compliance for Channel Erosion and Flooding:

The Following is one acceptable method to show compliance (VASWMH Chapter 5):

1. Calculate the Pre and Post Peak Runoff Rate.
2. Qo / Qi = Vs / Vr (VASWMH Section 5-4.2)

Qo = Allowable Discharge, cfs (existing 2- or 10-year Design Storm)
Qi = Inflow Discharge, cfs (Post Development)
Vs = Storage Volume (Detention Volume of Structure at Design Storm WSE)
Vr = Volume of Runoff entering structure

a. Solve Qo / Qi.
b. Compute $Vr = Qr * A * 43560 / 12$
    a. $Qr = (P - 0.2\ (1000/CN_{LID} - 10))^2 / (P - 0.8\ (1000/CN_{LID} - 10))$
    b. Qr = Depth of Runoff, inches
    c. P = Design Storm Depth, inches
    d. A = Drainage Area, acres
c. Use VASWMH Figure 5-4 to solve for Vs / Vr
d. Calculate Vs, $Vs = (Vs / Vr) * Vr$

3. Determine Detention Volume for the Allowable Discharge (2-, and 10-yr)
   Detention Volume = Storage Volume – BMP Retention Volume

4. Determine Depth of Detention for the Allowable Discharge
Depth of Detention (head, ft) = Detention Volume / BMP Surface Area

5. Outlet Sizing:
    b. Outlet needs to match the receiving channel
        3. No Channel → Sheet Flow spillway (weir or level spreader)
        4. Pipe or Ditch → control orifice that meets allowable peak discharge
        5. Natural Channel → Sheet Flow (weir or level spreader) into flat vegetated buffer strip (at least 25 feet setback)
    c. Weir Structure (VASWMH page 5-46 Equation 5-9):
        3. $L = Qo / (C * H^{1.5})$
        4. L = Length of weir (ft)
        5. Qo = Allowable Discharge (2-, 10-year Design Storm, cfs)
        6. C = coefficient (3.0) see Spillway Spec. (VSWMH 3.02)
        7. H = Depth of Detention (head), ft
    d. Orifice Structure (VASWMH page 5-40 Equation 5-7):
        3. $D = (4 * a / PI)^{0.5}$
        4. D = diameter of pipe, ft
        5. $a = Qo / (C\ (2gH)^{0.5})$
        6. a = area of orifice, sq ft

7. Qo = Allowable Discharge (2-, 10- year Design Storm)
8. C = coefficient (0.6) see Spillway Spec. (VSWMH 3.02)
9. g = gravity (32.2 ft/ s^2)
10. H = Depth of Detention (head), ft

6. Show normal storm routing calculations to determine design meets adequate channel criterion and flood attenuation criterion (VASWMH Section 5-9).
   a. There will be no discharge for Retention BMPs until the basin reaches its ponding elevation.
   b. Route the 2, 10, and 25 year storm events.
   c. If a structure doesn't have adequate detention volume, provide additional detention downstream of the structure and pass the excess flow.

II. Showing Water Quality Compliance:

- BMP ponding area sized for the LID Design Storm
- Selected BMP has adequate pretreatment structures
- LID is effectively a Technology-based method and BMP design in accordance with the VSWMH and Technical Bulletin #4. The Performance-based method is also acceptable.
- Uncontrolled runoff is limited to undisturbed areas

III. Minimum Standard 19 (Adequate Channel)

- Provide Channel Cross-Sections for each onsite conveyances and at least three Cross-Sections for offsite receiving conveyances.
- Provide routing calculations in accordance with the applicable design storms
  - Natural Channel: Show 2-year design storm velocity and depth of flow.
  - Man-Made Channel: Show 2-year design storm velocity and 10-year design storm depth of flow.
  - Pipe structures: Show 10-year design storm depth of flow.
- Stormwater conveyances must maintain the design storm depth of flow.
- Stormwater conveyances must maintain design storm flow velocity within applicable permissible velocity values. (non-cohesive channel materials should utilize the tractive force method, VDOT Drainage Manual Section 7.4.6.2)
- Stormwater conveyances must maintain design storm flow in a manner that maintains physical, chemical, and biological integrity of natural waterways.

10.29 Appendix 29 Culpeper SWCD Stormwater Management Checklist

March 2005 (Revised September 2008)

Below is a checklist of all necessary components required to complete all Stormwater Management Plans submitted to the Culpeper Soil and Water Conservation District (CSWCD) as in accordance with the Virginia Stormwater Management Law, Title 10, Chapter 6, Article 1.1 of the Code of Virginia and Virginia's Stormwater Management Regulations (4VAC 3-20-10). The Plan preparer must sign, date, and attach the checklist to any Stormwater Management Plan to be reviewed by the CSWCD.

For questions please call the CSWCD at (540) 825-8591. Application forms for the 1999 Virginia Stormwater Management Handbook, 1st Edition, and the Virginia Stormwater Management Program Permit Regulations (4VAC50-60-60) may be obtained from the CSWCD office or online at http://www.dcr.virginia.gov/sw/stormwat.htm.

I. Plan Narrative

a. ___ General project description

b. ___ Description of erosion and sediment controls

c. ___ Description of permanent Stormwater management facilities.

d. ___ Describe non-structural practices to improve water quality

e. ___ Project schedule, including sequence of construction and phasing

f. ___ Describe how the site plan meets the stormwater requirements for the VSMP permit and/or Erosion Control Regulations (Quantity, Quality and Channel Erosion).

g. ___ Natural Resource Assessment (if applicable)

i. ___ Describes features to be preserved (wetlands, forests, existing ponds and streams)

ii. ___ Environmentally sensitive areas to be protected (wetlands, steep slopes, prime soils)

II. Hydrologic Design

a. Rational Method

i. ___ Drainage area is homogenous and less than 200 acres

ii. ___ Provide worksheets with the determinations of "C" values and Time of Concentration (T_c).

iii. ___ Indicate rainfall intensities based on location of site and T_c.

iv. ___ Correction factor for ground saturation (Cf = 1.0 for 10-year events; 1.1 for 25-year events; 1.25 for 100-year events)

v. ___ Pre and Post development Hydrographs for each design storm.

vi. ___ Drainage area delineated on a legible drawing indicating existing and proposed improvements and contours. Each area delineated with respect to the point of concentration and acreage. Off-site drainage area delineated on a topographic map or other appropriate documents.

b. Peak Discharge (TR55) Method

i. ___ Drainage area is heterogeneous and more than 200 acres

ii. ___ Completed worksheets with determinations of Hydrologic Soil Group, Curve Number (CN), Time of Concentration (T_c), Rainfall depth (in) and unit discharge factor (q_u)

iii. ___ Pre and Post development Hydrographs for each design storm

iv. ___ Drainage area delineated on a legible drawing indicating existing and proposed improvements and contours. Each area delineated with respect to the point of concentration and acreage. Off-site drainage area delineated on a topographic map or other appropriate documents.

III. Hydraulic Design

a. ___ Drainage system outfalls at adequate channel. Adequate channel cross-section and calculations provided.

b. ___ Drainage systems provide overland relief of 100-year storm event without increasing flooding potential of nearby facilities.

c. Storm Sewers/Culverts/Ditches
   i. ___ Drainage design computations, as required by VDOT Drainage Manual
   ii. ___ Construction information (invert elevations, type of pipe, size, length and percent slope)
   iii. ___ Surface water is not carried longer than 600 feet in the gutter and recommend 300 feet in vegetated ditches.

d. Drainage Easements
   i. ___ Extended to an adequate channel
   ii. ___ Swales draining runoff across more than 2 lots

e. ___ Rating curve for pond

f. ____ Stormwater pond maintains structural integrity during the 100-year storm.

g. ___ Riser structure and detail (VSWMH Spec 3.02)

h. ___ Reservoir routing hydrographs for each design storm

i. ___ Embankment details (VSWMH Spec 3.01)

j. ___ Cross sections for stormwater structures

IV. Stormwater Management – Any construction project that disturbs more than 1 acre must file a Virginia Stormwater Management Permit (VSMP) and meet all technical criteria laid out in VSMP regulation (4VAC50-60). The stormwater management plan should meet the following criteria:

a. Low Impact Development (LID) (if applicable)
   i. ___ LID Checklist & Narrative
   ii. ___ Full LID Implemented
      1. ___ Computations (Reqd Retention/Detention Volume)
      2. ___ Practices provide the Retention/Detention Volume.
   iii. ___ Partial LID Implemented
      1. ___ Computations (Reqd Retention/Detention Volume)
      2. ___ Practices provide 70% of Retention/Detention Volume

3. ___ Conventional practices satisfy County Standards

iv. ___ Limited LID Implemented

1. ___ Filtering practices utilized
2. ___ Disconnection maximized
3. ___ Minimized impervious surfaces
4. ___ Conventional practices satisfy County Standards

b. Quantity Control

i. ___ Ten-year post-developed peak runoff rate does not exceed the ten-year pre-developed runoff rate.

ii. ___ Linear projects (utilities, etc.) maintains disperse flows

c. Quality Control

i. ___ Performance-based method (see worksheets from Appendix 5D of the Virginia Stormwater Management Handbook)

1. ___ Situation 1
2. ___ Situation 2
3. ___ Situation 3
4. ___ Situation 4

ii. ___ Technology-Based method (see Table 1 in 4VAC50-60-60 of VSMPP Regulations)

iii. ___ Quantify impervious surface

iv. ___ Determine Pollution loadings and removal rate required to maintain pre-developed loads.

v. ___ Does the stormwater plan meet the removal requirements?

d. Channel Erosion

i. ___ Comply with Minimum Standard 19 of VAC50-30-40 of the Erosion and Sediment Control Regulations for conveyance channels (onsite/offsite).

ii. ___ Provide 24 hour extended detention for the one-year, 24-hour storm for the site (receiving channel).

V. BMPs

a. General – For all BMPs (including conventional dry ponds)

i. ___ Provide cross-section and construction specifications

ii. ___ Provisions for construction oversight (especially infiltration structures and new technology)
iii. ___ Maintenance Agreement
  1. ___ Maintenance Plan
  2. ___ Permanent easements
  3. ___ Responsible Party
  4. ___ As-Built Survey (if applicable)
iv. ___ Design integrated with erosion control plan

b. Riparian and Stormwater Buffers (Perennial and Intermittent stream channels)
  i. ___ All permanent structures are excluded from the buffer area
  ii. ___ An enforceable deed restriction or easement is proposed for the buffer on each lot.
  iii. ___ Restrictions include no disturbance for permanent features (residences, out-buildings, roads/parking)
  iv. ___ Limits of Construction are completely outside the buffer

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CERTIFICATION OF PLAN PREPARER:

I certify that the above checklist items are fulfilled in the attached stormwater management plan, unless I have attached a written variance request for the omitted components.

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(signature of plan preparer) (date)

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(print name) (phone number)